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Analýza efektivnosti čínských komerčních bank pomocí DEA

Efficiency Analysis of Chinese Commercial Banks with DEA Approach

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3. Description and Analysis of Selected Banks
4. Application of Selected Models to Evaluate the Banks' Efficiency
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Bibliography
List of Abbreviations
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Annexes

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The Declaration

Herewith I declare that I elaborated the entire thesis, including all annexes, independently.

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Contents

1. Introduction

As we all know, one of the main goals of an enterprise is to make the maximum profits, however, what is the optimal amount of inputs to make the profits maximum can be a problem to each enterprise. For example, it one company wants to earn some profits, how much should the costs expend will be a problem for its managers. For about this problem, we name it as “efficiency”.

Efficiency is the ability to avoid wasting material, energy, efforts, money and time while doing something or producing something. More generally, it is the ability to do things better and better, more successfully and without waste. More mathematical terms, it is a measure of the extent to which inputs has been well used for an intended task or function which we calls “output”. It usually specially by the ability of a specific application of efforts to produce specific results with minimum quantity or amount of waste, cost, or unnecessary effort. Of course, efficiency is to point to different input and output efficiency in different areas and industries.

In order to measure the ability of efficiency of one enterprise we usually use DEA models. DEA model is used to empirically measure productive efficiency of decision making units (DMUs). Which was firstly proposed by Farrell in the year of 1957.

In our thesis, Chinese commercial banks’ efficiency performance will be measured and analyzed. We choose 12 Chinese commercial banks which includes, large scale commercial banks, medium and small scale commercial banks, stated commercial banks and regional commercial banks. By using DEA model for these banks, we can obtain the current efficiency level of Chinese commercial banks, and there reference set which help us to know how they should improve their efficiency performance in order to make the situation better and be more competitive.

The main objective of our thesis is to measure and analyze the efficiency performance of Chinese commercial banks by using DEA models. In detail, we will use two models of DEA which are CCR model (Charns, Cooper and Rhodes), the most basic DEA model, it is also a typical radial model, and SBM model (Slacks-Based

Measure), the model based on CCR and it is a non-radial model.

There are five chapters in this thesis, first it the introduction, we describe the main goal of our thesis.

Chapter 2 we talk about the models to evaluate the efficiency, in this chapter, DEA model will be described in detail, and we will also introduce more on the two models that we will apply in Chapter 4. And the software to apply DEA models will be also describe in this chapter.

Then in Chapter 3, the basic information of selected banks will be introduced. In this chapter, we will divide our banks into 2 groups. Then we will describe the main environment of Chinese banking system, and make short SWOT analysis for it. And we will talk something about their financial situation as well.

Chapter 4, is the main chapter of this thesis. In this chapter, we will measure and analyze the efficiency situation by applying CCR and SBM model. While firstly we will make the financial analysis of our selected banks, then CCR and SBM models will be applied.

Last chapter is conclusion, in this chapter, we will write what we find from previous chapter, and the main problems of selected banks. We will make the summary for our whole thesis.

2. Models to Evaluate the Efficiency

In people's productive activities and social activities often encounter such a problem: after a period of time, the need for the same type of department or unit (called the decision-making unit) to evaluate, the evaluation is based on the decision-making unit “input” Data and “output” data. The input data refers to the amount that the decision-making unit needs to consume in some kind of activity, such as the total amount of funds invested, the total labor force invested, the area occupied, etc. The output data is the result of the input of the decision unit after a certain input the amount of information that the activity has achieved, such as the number of different types of products, the quality of the product, the economic benefits, and so on. More specifically, in our thesis, the banks’ total assets, operating expenses and number of employees can be as the items of inputs and the banks’ operating profits, new deposits, new loans and ROE can be the items of outputs.

This kind of analysis can be called “efficiency analysis”, which can help managers to know the efficiency of producing the amount of products of different corporates with the same type. For the efficiency analysis, the most popular model is data envelopment analysis model, which was firstly proposed by famous operational scientist*s A. Charnes*, *W. W. Cooper* and *E. Rhodes* in order to evaluate the relative effectiveness of departments (hence known as DEA effective).

Data Envelopment Analysis (DEA) can be seen as a new method of statistical analysis. It is based on a set of observations on the input-output to estimate the effective production frontier. In economics and econometrics, it is estimated that the effective production frontier, usually using statistical regression and other statistical methods, these methods estimate the production function does not show the actual frontier, that the function is actually invalid of. Because this estimate is a combination of effective decision-making units and non-effective decision-making units. In addition to the DEA methods, there are other ways of evaluating effectiveness, but those methods are limited to single-output situations. In contrast, the ability of the DEA approach to handle

multiple inputs, especially multiple output problems, is an absolute advantage. Moreover, the DEA method can not only use the linear programming to determine whether the corresponding point of the decision unit is located on the frontier of the effective production, but also obtain a lot of useful management information. Therefore, it is superior to other methods (including the use of statistical methods), more useful and wider.

Hence, in this chapter we will mainly introduce the model which we will use for our thesis – Data Envelopment Analysis model. Firstly we make some general introduction of DEA model and then we will describe some basic models of this model. And in detail, we will mainly introduce the basic DEA model which is CCR model, it is the typical radial DEA model and the origin and base of other models. And then we will introduce the SBM model, which is typical non-radial model in the DEA model.

2.1 Basic introduction of Data Envelopment Analysis

As we know, Data Envelopment Analysis is a kind of nonparametric method which in operations research and economics for the production frontiers estimating. It is a very famous method to measure the efficiency of the organizations.

By explicitly consider the use of various inputs (resources) and the production of a variety of output (i.e., services), the DEA model can be used to compare with similar service efficiency between multiple service units

The general factors of the DEA model are inputs, outputs and DMUs which means Decision Making Units.

In fact, DEA model is a kind of linear programming model, which expressed as the ratio of output to input. Based on the efficiency of a particular unit and a set of similar units to provide the same service performance comparison, it tries to maximize the efficiency of the service unit. And in the process, with 100 % efficiency of some units called relative efficient units, and the other efficiency rating of less than 100 % of this is referred to as inefficient units.

DEA model avoids the measure the standard cost of each service, because it can

be transformed multiple input and multiple output as an efficiency ratio of the molecular and the denominator, therefore there is no need to convert the same monetary unit. Hence, measured by DEA efficiency can clearly shows that the combination of input and output, thus, it is a set of business ratios or profit targets is more comprehensive and more reliable.

The general measure form of the DEA model is as follows：

$$Efficiency = \frac{Output}{Input} \tag{2.1}$$

From this function we can find the more output amounts and / or less input amounts can lead to the more efficiency score.

For the factor DMUs (Decision Making Units) which Philip Kotler[1] defines it as "all individuals and groups that take part in the decision-making process relating to the negotiation of products or services".

For the DMUs there are six roles: users, influencers, buyers, initiators, deciders and gatekeepers. The users are the persons who will work with the purchased goods and services and impose on the norm, and customers and employees can take on this role; the influencers can be set through the precondition to influence purchasing process, they can be found in all levels in the organization; The buyer is the actual negotiations with suppliers, the buyer's is one of the most important role in the decision making units; the initiator is the player that identifies the problem and tries to find a solution for this problem, this is the most important person in the decision unit or DMU; the decider is the player who is responsible for selecting the supplier's overall, and thus occupies an important position in the decision-making unit or the DMU; the gatekeeper is responsible for providing information within the decision unit or DMU, the gatekeeper determines the type of information that will be passed to a player, and as a result

In our thesis the Chinese banks we selected are regard as the DMUs.

In order to make the DEA model's final result much more reliable, which is

[1] *Philip Kotler* (1931) is a reputable professor in the area of International Marketing at the Kellogg School of Management which is the business School of Northwestern University. He is also the founding father of the famous marketing management theories: DMU and the five product levels.

required that the number of DMUs (we regard it as n) should exceed the combined number of outputs and inputs which we regard as "$s + m$" and then we obtain the function as follows:

$$n = max\{m \cdot s, 3 \cdot (m + s)\} \tag{2.2}$$

In previous chapter we have already selected the items of inputs and outputs, for inputs we choose total assets, operating expenses and number of employees as its items and the items of outputs are operating income, new deposits, new loans and ROE. We use these two groups to analysis the efficiency of the twelve selected banks. And these 12 banks we regard them as the DMUs.

We can divide the DEA model into two types which are radial and non-radial when measuring input and output data. The radial DEA model means that the change of efficiency valves are proportional. For example, if now we have the inputs value x_1 and x_2, and both of them are radial, and then we can say their activity (x_1, x_2) is proportionally which we can write as (tx_1, tx_2), here the t is positive. For the typical radial DEA model, we will introduce the CCR model later. On the contrary, non-radial DEA model means that the change of efficiency values are not proportional. Correspondingly, this method ignores the radial characteristics of variables. For the typical non-radial DEA model, we will describe the SBM method later in this chapter, it reflects both the efficiency value and the slacks.

The model also has two orientation indicates which are input-oriented and output-oriented. The first one means that the model is aim to research the efficiency by input level while keeping the output at least at the current level, in contrast, the second one means that the model evaluates efficiency through output levels without any more observed input level. In our thesis, we prefer to use the former one.

There are three cases of the efficiency, which are: 1. if and only of the DMU satisfies: a. the efficiency in the best case is equal to one and b. the full efficiency that cannot be achieved when the output is defect is or input is exceeded; 2. if the DMU reaches the full efficiency condition: a. while the relaxation is not restricted, the efficiency or technical efficiency is low; 3. otherwise, the DMU is inefficient.

In face there are some several kind model of DEA, for example, CCR mode, it is

the most basic method in DEA model; BBC model, which is an extension version of CCR model from CRS to VRS; Additive model, which has the same production possibility set as CCR and BCC and their variants, however treats and slacks directly in the objective function; SMB model, which is a non-radial model based on CCR model.

There are a lot of model in DEA models, we just make some short examples, in our thesis we will mainly use the basic DEA model which is CCR model, and the typical non-radial model named SBM model.

Hence, in the next sections we will introduce these two models clearly.

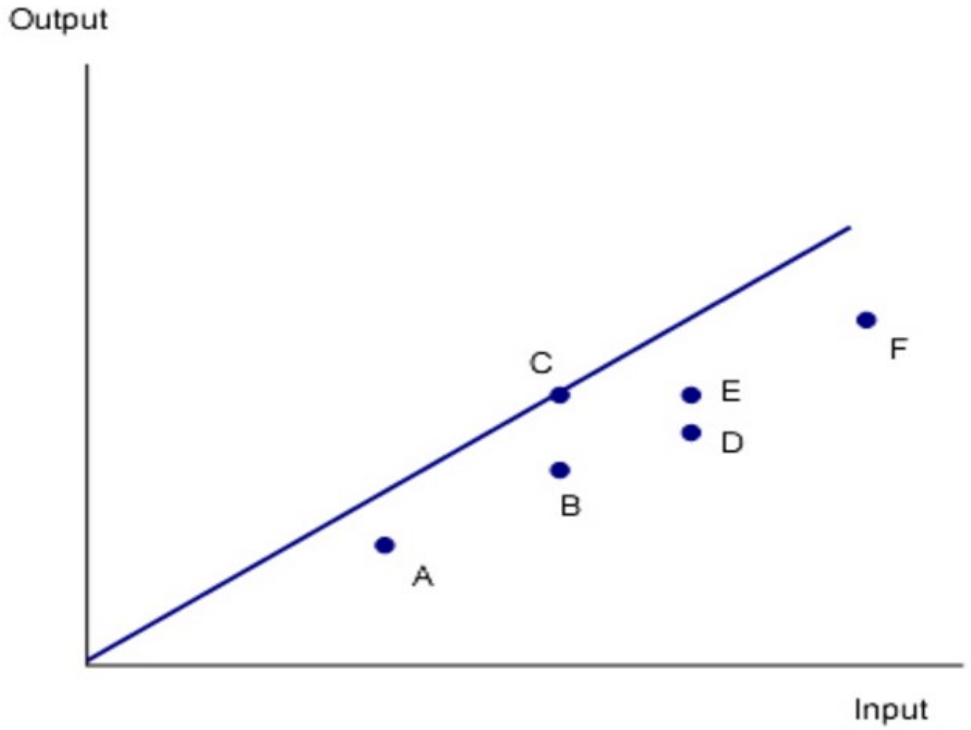
2.2 CCR Model

CCR model is the basic model of DEA model, which is the typical radial model and the origin and base of other models as well.

It is the model to evaluate the efficiency of a set of similar DMUs with multiple inputs and multiple outputs, which is initially proposed by Charnes, Cooper and Rhodes in the year of 1978.

The assumption of the CCR model is constant return-to-scale of activities, where the constant return-to-scale means if all of the inputs increasing 100 per cent, the new value of output will increasing at the same proportion to the point on the production frontier, which is shown at the following figure.

Figure 2.1 Production Frontier of CCR Model



We suppose that there are n DMUs, then we can say DMU_j, (j = 1, … , n). And we suppose the input is m while the outputs is *s*, $y_j = (y_{1j}, \dots, y_{sj})$. And one DMU has at least one positive input and one positive output because it is impossible to be assumed no input and no output for a DMU. And all of the outputs and inputs as assumed to be equal to or higher than zero which means that they are nonnegative at all.

From this we can express the DMU_j by the input data and the output data which are:

$$x_j = (x_{1j}, x_{2j}, x_{3j}, \dots, x_{mj}); (\, x_j \geq 0;\ \exists\, x_j \neq 0; j = 1, 2, 3, \dots, n) \qquad (2.3),$$

$$y_j = (y_{1j}, y_{2j}, y_{3j}, \dots, y_{sj}); (\, y_j \geq 0;\ \exists\, y_j \neq 0; j = 1, 2, 3, \dots, n) \qquad (2.4)$$

For the *X* and *Y* data matrixes which can be express as following:

$$X = [\, x_1, x_2, \dots, x_n] = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \in R^{(m \times n)} \qquad (2.5)$$

$$Y = [\, y_1, y_2, \dots, y_n] = \begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \vdots & \vdots & & \vdots \\ y_{s1} & y_{s2} & \cdots & y_{sn} \end{bmatrix} \in R^{(s \times n)} \qquad (2.6)$$

The feasible activity group of (x, y) is called production possibility set, here the

(x, y) satisfies that $x \geq X\lambda$ and $y \leq X\lambda$ (here λ is a semi-positive vector in Rn; $\lambda \geq 0$). Each of such vector can be regard as a semi-positive quadrant point in the $(m + s)$ dimensional linear vector space, and here the m and s means the amount of dimensional required of inputs and outputs.

As for the unknown weights of inputs and outputs, we regard then as: m-vector $v = (v_1, v_2, \dots, v_m)$ and s-sector $u = (u_1, u_2, \dots, u_s)$, we always call these weights as multipliers or shadow prices. And as we all know, the DEA model is based on some mathematical models in order to find out every DMU's optimal weights. While in fact, each DMU's optimal weight can be different. Following is the ratio about measuring the efficiency of one unit under evaluation, DMUo, (o = 1, … , n).

$$\frac{uy_o}{vx_o} = \frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{i=1}^{m} v_i x_{io}} \tag{2.7}$$

Here, v_{xo} and u_{yo} means the virtual input and virtual output.

If, the virtual output to the virtual input is equal to lower than one for all DMUs, which means the efficiency score of DMUo is related to the performance of other DMUs.

2.2.1 The Efficiency of CCR Model

From previous Formula (2.7), we can obtain the following fractional program (FPo) way to measure the efficiency score of DMUo:

$$\begin{aligned} (FPo) \qquad & max_{v,u}\theta = \frac{uy_o}{vx_o} \\ & \frac{uy_j}{vx_j} \leq 1 \qquad j = 1, 2, 3, \dots, n \\ & v \geq 0; u \geq 0 \end{aligned} \tag{2.8}$$

Here, v and u means the weight vectors of inputs and outputs while the v_{xo} and u_{yo} means the virtual input and virtual output. And the range of the result of θ belongs to [0, 1].

Besides the fractional program, another program is linear program (LPo) which can be expressed as following:

$$(LPo) \qquad max_{v,u}\theta = uy_o$$

$$vx_o = 1$$
$$\frac{uy_j}{vx_j} \leq 1 \quad j = 1, 2, 3, \dots, n$$
$$v \geq 0; u \geq 0 \tag{2.9}$$

In fact, *LPo* is equivalent to *FPo*.

We suppose that the (θ*, *v**, *u**) is the optimal solution of these formulas. And then we can say the DMU*o* is CCR-efficient if and only if:

(a). θ* = 1;

(b). there exists at least one optimal (*v**, *u**) where *v** > 0, *u** > 0.

If it does not satisfy these condition, then DMU*o* is CCR-inefficient.

The formulas previous use the θ* to measure the efficiency, it does not consider the non-zero slack. Therefore, we will now introduce a real variable θ and a non-negative vector $\boldsymbol{\lambda} = (\lambda_1, \lambda_2, \dots, \lambda_n)^T$ and the investigate the dual problem of (*DLPo*) which is shown as following:

$$(DLPo) \quad min_{\theta,\lambda} \quad \theta$$
$$\theta x_o - X\lambda \geq 0$$
$$Y\lambda \geq y_o$$
$$\lambda \geq 0 \tag{2.10}$$

We assume the output shortfalls $s^+ \in R_s$ and the input excesses $s^- \in R_m$ and identify them as the "slack" vectors by the following formula.

$$s^- = \theta x_o - X\lambda, s^+ = Y\lambda - y_o$$
$$s^- \geq 0, s^+ \geq 0 \tag{2.11}$$

Here the solution of (*DLPo*) is (θ，λ). And we also use the θ* as the optimal situation; use the ω^* to represent ω where $\omega = \omega_x s^- + \omega_y s^+$ when there is in optimal situation, where ω_x and ω_y are positive row vector. Here if and only if the θ* = 1 with zero-slack, the DMU*o* is CCR-efficient.

2.2.2 Efficiency Improvement of CCR

If the DMU*o* is CCR-inefficient, it can be improve by augmenting output shortfalls

and eliminating the input excesses consulting the reference.

Then we can find the gross input improvement which is expressed as Δx_o and gross output improvement which is expressed as Δy_o can be measured by the following way.

$$\Delta x_o = (1 - \theta^*)x_o + s^{-*}$$
$$\Delta y_o = s^{+*} \tag{2.12}$$

After that (x_o, y_o) will be the improved activity ($\widehat{x_o}$,$\widehat{y_o}$) we call it as CCR projection. The ($\widehat{x_o}$,$\widehat{y_o}$) is the full efficient combination.

$$\widehat{x_o} \leftarrow \theta^* x_o - s^{-*}$$
$$\widehat{y_o} \leftarrow y_o + s^{+*} \tag{2.13}$$

Now, we use α_{oi} to express the input excess ratio and use β_{oj} to express the output shortfall, then we can obtain:

$$\alpha_{oi} = 1 - \theta_o + \frac{s_{oi}^-}{X_{oi}} \qquad (i = 1, 2, 3, \dots, m)$$
$$\beta_{oi} = \frac{s_{oj}^+}{Y_{oj}} \qquad (j = 1, 2, 3, \dots, s) \tag{2.14}$$

2.3 Slacks-Based Measure of Efficiency (SBM)

The CCR model we describe in previous subchapter is a typical radial model, it reflects the proportional maximum input or outputs reduction rate which is common to all inputs or outputs. However, in fact, not all inputs or outputs behave in the proportional way. In many situation, we can find many remaining non-redial slacks. Hence, in this subchapter we will introduce the non-redial measurement model which called Slacks-Based Measure of Efficiency (SBM).

SBM model is proposed by Tone in the year of 1997, is measures technical efficiency and slacks in a single scalar.

SBM model does not have the assumption that the input and output will change in proportionate way, it deals with slack directly.

When we use the SBM model we should satisfy following two conditions:

(a). *Units invariant*: the measure must be invariant with respect to the units of data;

(b). *Monotone*: the measure must be decreasing monotonously in each slack in output and input.

SBM model loosen the assumption of constant returns-to-scale. We assume that the returns-to-scale is variable, it also includes the constant returns-to-scale, decreasing returns-to-scale and increasing returns-to-scale.

From this we assume X_i where $i = 1, 2, 3, \dots, m$ are m kinds of inputs and then we can obtain 3 result of the production function of $F(X_i)$ which are:

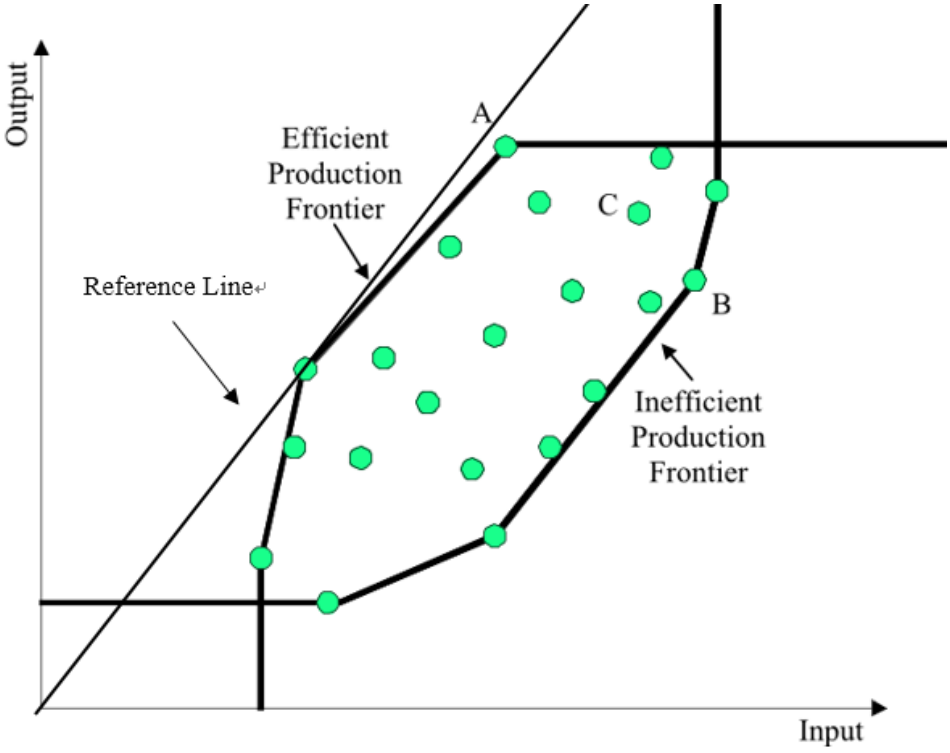
(a). $F(\alpha X_i) > \alpha F(X_i)$, it means there is *decreasing* returns-to-scale;

(b). $F(\alpha X_i) = \alpha F(X_i)$, it means there is *constant* returns-to-scale;

(c). $F(\alpha X_i) < \alpha F(X_i)$, it means there is *increasing* returns-to-scale.

For the increasing returns-to-scale, which means if all of the inputs increasing by 100 per cent, then the new values of outputs will be more than twice higher than the former outputs, this can be result from specialized operating and the diminishing margin cost. For the decreasing returns-to-scale, which means if all of the inputs increasing by 100 per cent, then the new values of outputs will be more than twice lower than the former outputs, this can be result from the managerial problems.

Figure 2.2 Production Frontier of SBM Model



From the Figure 2.2 we can see the production frontier curve of SBM, and also find out the efficient production frontier and the inefficient production frontier, this we will describe more clearly in the next subpart. By the way, the reference line which starts from the origin is thorough the point which satisfies CCR efficiency, its slope is 1.

As from the figure, we can see the production frontier of SBM is not beginning from the origin but start from higher point. From the first and second line in the efficient production frontier we can find they are in the increasing returns-to-scale and during the third and fourth parts they are in the decreasing returns-to-scale; while after then, the point will satisfies the constant returns-to-scale.

2.3.1 The Efficiency of SBM Model

During this part we will talk about the efficiency of SBM in detail which has been shown on Figure 3.2.

First for the fractional programs of SBM which we can also use λ, s^-, s^+ to express as following:

$$(SBM) \qquad min_{\lambda,\, s^-,\, s^+}\ \rho = \frac{1-\frac{1}{m}\sum_{i=1}^{m}\frac{s_i^-}{x_{io}}}{1+\frac{1}{s}\sum_{r=1}^{s}\frac{s_r^+}{y_{ro}}}$$

$$x_o = X\lambda + s^-$$

$$y_o = Y\lambda - s^+$$

$$\lambda \geq 0, s^- \geq 0, s^+ \geq 0 \qquad (2.15)$$

Here in this formula, we suppose that X is higher than zero. And if x_{io}= 0, we will ignore $\frac{s_i^-}{x_{io}}$. And if y_{ro} is equal or lower than zero, we will use a very small positive number to replace it, and then we are able to keep $\frac{1}{m}\sum_{i=1}^{m}\frac{s_i^-}{x_{io}}$ in the range from 0 to 1, this can be regarded as the average value of input slack's relative rate.

We can also use the form $\frac{1}{m}\sum_{i=1}^{m}\frac{(x_{io}-s_i^-)}{x_{io}}$ instead of the form $1-\frac{1}{m}\sum_{i=1}^{m}\frac{s_i^-}{x_{io}}$, here it means the proportional reducing of the mix inefficiency of input. Analogously, the

form $1+\frac{1}{s}\sum_{r=1}^{s}\frac{s_r^+}{y_{ro}}$ means the relative rate of the mix inefficiency of output which should be no less than one. Therefore, we can find out that the final result of ρ will in the range of [0, 1].

If and only if $\frac{1}{m}\sum_{i=1}^{m}\frac{s_i^-}{x_{io}}=0$ and $\frac{1}{s}\sum_{r=1}^{s}\frac{s_r^+}{y_{ro}}=0$, from this result we will obtain the result of ρ who is equal to 1.

Because during this thesis we will focus on the input-oriented model, therefore we will transform the formulas above to the following formula.

$$(SBM\text{-}I)\quad min_{\lambda,s^-,}\,\rho = 1-\frac{1}{m}\sum_{i=1}^{m}\frac{s_i^-}{x_{io}}$$

$$x_o = X\lambda + s^-$$

$$y_o = Y\lambda$$

$$\lambda \geq 0, s^- \geq 0, \qquad (2.16)$$

We assume that the optimal situation of Formula (2.16) is ρ_I*. We can obtain ρ_I* = 1 when there is no output shortfalls and input excesses, and the s^-* = 0 and s^+* = 0.

Hence, here if and only if ρ_I* = 1, the DMU (x_o, y_o) is SBM-efficient.

2.3.2 Efficiency Improvement of SBM

If the DMU (x_o, y_o) is SBM-inefficient, we can use the optimal situation λ^*, s^{-*} and s^{+*} to express it as following formula.

$$x_o = X\lambda^* + s^{-*}$$

$$y_o = Y\lambda^* - s^{+*} \qquad (2.17)$$

By eliminating the input excesses and augmenting output shortfalls we can improve the SBM-inefficient DMU (x_o, y_o). And then it will be the improved activity ($\widehat{x_o}$, $\widehat{y_o}$) we call it as SBM projection. And the ($\widehat{x_o}$, $\widehat{y_o}$) is the full efficient combination, the set which is constituted by ($\widehat{x_o}$, $\widehat{y_o}$) is the reference set.

$$\widehat{x_o} \leftarrow x_o - s^{-*}$$

$$\widehat{y_o} \leftarrow y_o + s^{+*} \qquad (2.18)$$

Now, we use α_{oi} to express the input excess ratio and use β_{oj} to express the output shortfall, and then we can obtain:

$$\alpha_{oi} = \frac{\bar{s_{oi}}}{X_{oi}} \qquad (i = 1, 2, 3, \dots, m)$$

$$\beta_{oi} = \frac{s_{oj}^{+}}{Y_{oj}} \qquad (j = 1, 2, 3, \dots, s) \tag{2.19}$$

2.4 DEA-Solver

In this part we will talk about the software we use for measuring the DEA models.

It is called "*DEA-Solver*". And there are two versions of it, one is "Learning Version" (called *DEA-Solver-LV*), another is "Professional Version" (called *DEA-Solver-PRO*).

DEA-Solver was developed by Kaoru Tone, all of the responsibility is attributed to Tone, but not to Cooper and Seiford in any dimension.

We can find this software in the website at: heep://www.saitech-inc.com/.

In our thesis, we will use the Version 8.0 of *DEA-Solver-LV*. And the Version 8.0 consists of 28 cluster.

Table 2.1 Clusters of Version 8.0

No.	Cluster	Model
1	CCR	CCR-I, CCR-O
2	BCC	BCC-I, BCC-O
3	IRS	IRS-I, IRS-O
4	DRS	DRS-I, DRS-O
5	GRS	GRS-I, GRS-O
6	AR (Assurance Region)	AR-I-C, AR-I-V, AR-I-GRS, AR-O-C, AR-O-V, AR-O-GRS
7	NCN (Non-Controllable)	NCN-I-C, NCN-I-V, NCN-O-C, NCN-O-V
8	NDSC (Non-Discretionary)	NDSC-I-C, NDSC-I –V, NDSC-I –GRS, NDSC-O-C, NDSC-O-V, NDSC-O-GRS
9	BND (Bounded Variable)	BND-I-C, BND-I-V, BND-I-GRS, BND-O-C, BND-O-V, BND-O-GRS

10	CAT (Categorical Variable)	CAT-I-C, CAT-I-V, CAT-O-C, CAT-O-V
11	SYS (Different Systems)	SYS-I-C, SYS-I-V, SYS-O-C, SYS-O-V
12	SBM-Oriented (Slacks-based Measure)	SBM-I-C, SBM-I-V, SBM-I-GRS, SBM-O-C, SBM-O-V, SBM-O-GRS, SBM-AR-I-C, SBM-AR-I-V, SBM-AR-O-C, SBM-AR-O-V
13	SBM-Non Oriented	SBM-C, SBM-V, SBM-GRS, SBM-AR-C, SBM-AR-V
14	Weighted SBM	WeightedSBM-C, WeightedSBM-V. WeightedSBM-I-C, WeightedSBM-I-V, WeightedSBM-O-C, WeightedSBM-O-V
15	Super-SBM-Oriented	Super-SBM-I-C, Super-SBM-I-V, Super-SBM-I-GRS, Super-SBM-O-C, Super-SBM-O-V, Super-SBM-O-GRS
16	Super-SBM - NonOriented	Super-SBM-C, Super-SBM-V, Super-SBM - GRS
17	Super - Radial	Super-CCR-I, Super-CCR-O, Super-BCC-I, Super-BCC-O
18	Cost	Cost-C, Cost-V, Cost - GRS
19	New-Cost	New-Cost-C, New-Cost-V, New-Cost-GRS
20	Revenue	Revenue-C, Revenue-V, Revenue-GRS
21	New - Revenue	New-Revenue-C, New-Revenue-V, New-Revenue-GRS
22	Profit	Profit-C, Profit-V, Profit-GRS
23	New - Profit	New-Profit-C, New-Profit-V, New-Profit-GRS
24	Ratio (Revenue/Cost)	Ratio-C, Ratio-V
25	Bilateral	Bilateral-CCR-I, Bilateral-BCC-I, Bilateral-SBM-C, Bilateral-SBM-V
26	Window	Window-I-C, Window-I-V, Window-I-GRS, Window-O-C, Window-O-V, Window-O-GRS
27	FDH	FDH
28	Malmquist-Radial	Malmquist-Radial-I-C, Malmquist-Radial-I-V, Malmquist-Radial-I-GRS, Malmquist-Radial-O-C, Malmquist-Radial-O-V, Malmquist-Radial-O-GRS

Here are four proceeds of the *DEA-Solver*, which are:

(1) Selection of a DEA model

(2) Selection of a data set in Excel Worksheet

(3) Selection of a Workbook for saving the results of computation

(4) DEA computation

After applying the *DEA-Solver* software, we will obtain some worksheets in our Excel which includes:

a). "Slack", it contains the input excesses (s^-) and output shortfalls (s^+) for each DMU.

b). "Projection", it refers to the projections of each DMU onto the efficient frontier analyzed by the model we chosen.

c). "Graph1" and "Graph2", both of these worksheets are graphsheets, which shows the DEA score by using bar chart, and graph2 is graph1 in the ascending order.

d). "Rank", it refers to the rank of all DMUs according to score.

e). "WeightedData" and "Weight", these two worksheets contain the weight of each item for each DMU.

f). "Score", it refers to the DEA-score, reference set, lambda-value for each DMU in the reference set and also ranking of them by the efficiency scores.

g). "Summary", in this worksheet we can see the statistics on data and a summary report of the result we obtained.

h). "OriginalData", this worksheet is the original data of each DMUs we put to use DEA-Solver.

i). "RTS", which shows return-to-scale characteristics in the worksheet. And the return-to-scale characteristics are those of the input or output projected DMUs on the frontier. There are three kinds of return-to-scale characteristics which are decreasing return-to-scale, constant return-to-scale and increasing return-to-scale.

Hence, by using the worksheets obtained from *DEA-Solver* we can clearly analyze the efficiency situation of all DMUs we selected.

However, there also some data limitations when we apply the *DEA-Solver*

software.

Firstly, it has the "*Problem Size*", which requires that the number of DMUs must by equal to or less than 50.

Secondly, "*For the Numerical Accuracy Sake*", when comparing a very large DMU and the DMU within a very small set of data may result in a loss of numerical accuracy in the obtained score. In some cases, this will result in an infeasible or unbounded LP solution. Hence, we recommend that in an input or output item, the ratio of data to the minimum / maximum average is greater than 10^{-4}. In order to avoid this kind of trouble, grouping studies on a similar scale and analysis of each group would be beneficial.

2.5 Summary

In this chapter we mainly describe the principle of DEA model and its two basic and typical models which are CCR model and SBM model.

DEA model is a kind of nonparametric method which in operations research and economics for the production frontiers estimating. It is a very famous method to measure the efficiency of the organizations.

CCR model is the basic model of DEA model, which is the typical radial model and the origin and base of other models as well. It has the assumption of constant returns-to-scale of the activities. This model does not consider the output shortfalls and input excesses.

SBM model is a typical non-radial model which is an improved measure based on CCR model. It consider the output shortfalls and input excessed and it is in variable returns-to-scale.

Finally, we describe the software we will use for our thesis which named "*DEA-Solver*". For example, we describe the proceeds of it, and the results we will obtain from this software, and some data limitations of it as well.

3. Description and Analysis of Selected Banks

In this chapter we will introduce some basic information of the Chinese commercial banks, firstly we will describe the information of Chinese banking system, then is some basic data of the selected banks such as the financial statements, which are income statements and the balance sheets. This will be the basic data of the DEA model, we select 12 typical Chinese commercial banks which are Industrial & Commercial Bank of China Limited (ICBC), China Construction Bank (CCB), Bank of China (BOC), China Merchants Bank (CMBC), Bank of Communications (BOCM), Agricultural Bank of China (ABC), China CITIC Bank (CITIC), China Minsheng Banking Corp. LTD (CMSB), Shanghai Pudong Development Bank (SPDB), Industrial Bank Co. LTD (BIC), Bank of Beijing Co. LTD (BJB) and Bank of Hangzhou Co. LTD (HZB).

From the average operating incomes amounts of each bank, we can divide them into two groups which is shown in the following Table 3.1.

Table 3.1 Two Groups of the Selected Banks by Amount of Operating Income

Operating Income	higher than 400000 million CNY	Industrial & Commercial Bank of China Limited (ICBC)
		China Construction Bank Corp.(CCB)
		Agricultural Bank of China Ltd.(ABC)
		Bank of China Ltd.(BOC)
	lower than 400000 million CNY	China Merchants Bank Co. Ltd.(CMBC)
		Bank of Communications Co. Ltd.(BOCM)
		China CITIC Bank Co. Ltd.(CITIC)
		China Minsheng Banking Corp. Ltd. (CMSB)
		Shanghai Pudong Development Bank Co. Ltd.(SPDB)
		Industrial Bank Co. Ltd. (BIC)
		Bank of Beijing Co. Ltd.(BJB)
		Bank of Hangzhou Co. Ltd.(HZB)

3.1 Chinese Banking System

Before describe the banking system of China, we firstly tale about the principle of banking system.

Banking system means that what is the relationship between central bank and commercial banks. The establishment of a country's banking system depends on the country's political and historical conditions and economic development. As a result of the development of the world economy and imitation and other factors, the national banking system is basically the same. In general, the more perfect banking system by the central bank as the core, commercial banks as the main body, with a variety of professional banks and other financial institutions and composition.

There are two types for the banking system, which are on-stage system and two-stage system, the former one can also say that there is no central bank and all of banks are managed by governments. For about the two-stage banking system, the first stage is central bank, while the second stage is commercial banks, they are able to operate independently by the supervising of central bank, this kind of system is very common nowadays.

Imperial Bank of China was found in 1897, it was the first bank found by China self. During that time China bank industry mainly used the one-stage system while after 1984, China began to implement the two-stage banking system, but the commercial banks are still operated under the central bank’s order and the central bank is servicing for the government. In fact, Chinese banking system is in the process of reform, and after decades of communism and state ownership transition, China's banking system has transitioned to a more open and supportive China in the global economy. This program began in the early 1980s and continues to these days.

Chinese banking system used to be monolithic, with People’s Bank of China (PBC) which is the central bank, it is the main entity authorized to conduct operations in China. In early 1980s, government began to open up the banking system and there are four state owned specialized banks were allowed to accept deposits and conduct banking business. These four specialized banks are Industrial & Commercial Bank of China

Limited (ICBC), China Construction Bank (CCB), Bank of China (BOC) and Agricultural Bank of China (ABC), this is also one of the reason we select these four banks as parts our DMUs.

After 1995, independence of commercial banks in China had been increasing but still not high enough. In the year of 1998, “online banking” was appeared in China, but because it was a new thing that day, people did not pay much attention to it. But people nowadays are willing to use the online banking system such as the Zhifubao system.

The capital scale, profit after taxes of Chinese bank industry has been increasing year by year, and in the year of 2011, the profits of Chinese bank industry accounted for almost a third of global banking industry profits

On November, 12th 2007, the Federal Reserve agreed the application of China Merchants Bank Co. Ltd (CMBC) to build the subsidiary bank in New York which is the first Chinese bank in America. And in 2006, the amount of foreign direct investment of Chinese bank industry was about 2580 million dollars. This means Chinese bank industry’s overseas market has been developed these years.

China also allows more than a dozen joint-stock commercial banks and more than 100 city commercial banks to operate in the country. China also has banks committed to the country's rural areas. Foreign banks are also allowed to set up branches in China and to strategically digitize investments in many state-owned commercial banks. While in our project, our object is Chinese commercial banks, hence the DMUs we select mainly are commercial banks owned in China, the banks established by foreign countries will be ignored in this thesis. For about the type of commercial banks in China, there are state owned commercial banks, private commercial banks, national commercial banks and municipal commercial banks.

In order to make our analysis more all-sided, these four types will all included in our DMUs. First, as we say in previous paragraphs, the four specialized banks ICBC, BOC, CCB and ABC will be selected as a part of DMUs, all of them are state owned commercial banks. For about state owned commercial bank we also choose the Bank of Communications (BOCM) in order to make the thesis all-sided and avoid the monopoly of the data of state owned commercial banks. About the private commercial

banks we choose CMBC, CITIC, SPDB and CMSB, which are national banks as well, it means the scope of their business are all across the country. By the way, the five state owned commercial banks we selected are also the national commercial banks. For about municipal commercial banks we choose BJB and HZB, which means the scope of these banks are only one city, for example, we can see Bank of Beijing only in Beijing city, and its consumer is main local Beijing persons or someone who live there in long time.

Then we will make the SWOT analysis of Chinese bank industry. SWOT analysis can be divided into four parts which are strengths, weakness, opportunities and threats.

Strengths: as we know, Chinese banks are supported from government policy which can be the main strength in domestic of Chinese banks. Government will provide the fiscal and monetary help by central bank if there are some difficult in Chinese banks. In the oversea market, because of the well performance and good record to the customers, Chinese banks make the good achievements these tears.

Weakness: because of the lack of the investment philosophy, people usually choose the T-bills rather than other financial products and some people prefer to use electronic consumption instead of invest which lead to the lack of innovation of Chinese banks. In the oversea market, the lack of creativeness is also the problem for Chinese banks.

Opportunities: in the domestic market, the rural areas can be the potential market which is worth to exploit. For about the oversea market, broaden this market can help to improve the investment environment of Chinese banks.

Threats: the opaqueness of financial statements can be a big problem of Chinese banks. Because Chinese banks are over dependent on the central bank and government, the competition sense of Chinese banks are very lacking. Small banks in China are difficult to survival because of the monopolization of bank industry. Nowadays, the loss of talents has also become one of the big problem of Chinese bank industry.

3.2 Financial Statements

Financial statements are kinds of accounting document, which always reflect the bank over a fiscal period (mainly quarterly or annual) financial performance, and the end of the situation. It is to quantify the financial figures, and then express by classifying. The most useful financial statement for analyzing the situation of the bank as we all know are the income statement and balance sheet.

In this subchapter we will describe the financial statements of the Chinese commercial banks we selected, and the income statements and the balance sheets will be introduced in detail.

3.2.2 Income Statements

Income statement is one of the important part of bank's financial statement. In order to measure the profitability of the bank we must use the income statements.

For the data of financial statements we choose 5 years of each banks and the weight we use for each year is 2011 = 5%, 2012 = 7.5%, 2013 = 12.5%, 2014 = 25% and 2015 = 50%, in total is 100%.

Following table we can see the main part of income statements of banks.

Table 3.2 Main Part of Income Statement

Total Interest Income
Total Interest Expense
Net Interest Income
Provision for Loan and Lease Losses
Total Noninterest Income
Fiduciary Activities
Service Charges on Deposit Account
Trading Account Gains and Fees
Additional Noninterest Income
Total Noninterest Expense
Salaries and Employee Benefits
Premises and Equipment Expense
Additional Noninterest Expense
Pretax Net Operating Income
Securities Gains (Losses)
Taxes
Income before Extraordinary Items
Extraordinary Gains - net
Net Income

Source: own integration

In this table, the provisions of the income statement is the reserve of the bank for its impairment per year, while the total sum of the provisions is equal to the loan loss allowance in the balance sheet we will introduce later.

Following is the income statements of the banks we selected.

Table 3.3 Short Income Statements of 12 banks

	net interest income	noninterest income	operating income	operating expense	net profit
ICBC	482206.2	146496.5	**628702.7**	213329.7	269126.2
CCB	428637.3	122443.9	**551081.1**	189991.1	221387.1
ABC	413568.9	96975.1	**510544.0**	215286.0	173023.5
BOC	310724.1	135130.6	**445854.7**	177656.4	171949.0
BOCM	136296.1	42920.6	**179216.7**	96077.0	64427.8
CMBC	119172.0	53619.6	**172791.7**	61544.4	54495.2
CMSB	89574.7	48718.5	**138293.1**	79995.4	43690.0
BIC	102488.8	29131.0	**131619.8**	73280.4	45918.5
CITIC	95529.6	32137.2	**127666.8**	46096.9	31862.3
SPDB	100271.6	25947.0	**126218.7**	65908.5	46102.0
BJB	31784.7	6321.2	**38105.9**	19197.2	15359.7
HZB	9986.5	1303.9	**11290.3**	6866.8	3606.5
					Unit: million CNY

From the Table 3.3 above, we can see the income statements of the 12 commercial banks, for about the net profits, we can find that the industrial & Commercial Bank earns most which is about 269126 million CNY while the China CITIC Bank earns least which is about 31862 million CNY. And for about the operating income, ICBC is still the first who earns most is 628703 million CNY while the lowest one changes to SPDB which is about 126219 million CNY. For about BJB and HZB we can find their data is much lower than others because the scale of them are not as large as other banks. And this ranking is according to amount of operating income that each bank earns.

3.2.2 Balance Sheets

Balance sheet is another important part of bank's financial statement, from which we can see the useful information for the bank. And many of the financial ratios we measure should use the balance sheet as well. Balance sheet includes: assets which means the bank has toady, liabilities which means the amount that the bank owns and the equity which means the bank is worth now.

Following table shows us the main part of the balance sheet of the bank.

Table 3.4 Main Part of the Balance Sheet

Total Assets	**Total Liabilities and Capital**
Cash	**Total Liabilities**
Securities	Deposits
Federal Funds Sold	Federal Funds Purchased
Gross Loan and Leases	Trading Liabilities
Loan Loss Allowance	Other Borrowed Funds
Net Loan and Leases	Subordinated Debt
Trading Account Assets	All Other Liabilities
Banking Premises and Fixed Assets	**Total Equity Capital**
Other Real Estate Owned	Common Stock
Goodwill and Other Intangibles	Preferred Stock
All Other Assets	Surplus
	Undivided Profits

As for the asset's part, the item "loan loss allowance" can be presented as provisions in the income statement, and the loan loss allowance is the sum of all the provisions from the previous years. And the calculation of net loan can be measured as following:

$$Net\ Loans = Gross\ Loans - Loan\ Loss\ Allowance$$

The item "goodwill" is the difference between the market price of bank and the price of the bank. And for the part of liabilities, the subordinated debt is a kind of debt that with high risk, and it ranks after other but before capitals is the bank falls into the bankruptcy.

The following are the balance sheets of the 12 commercial banks we selected during 2011 to 2015 measure by the weight.

Table 3.5 Short Balance Sheets of 12 banks

	total assets	total loans	loan loss allowance	net loans	deposit	total liabilities	total equity
ICBC	20711606.9	11013334.3	261116.3	10752218.0	15494002.1	19134688.0	1576919.0
CCB	16943222.8	9573198.6	240542.1	9332656.5	12936918.3	15661379.3	1281843.5
ABC	16286701.8	8147066.2	363904.3	7783161.9	12674777.1	15228196.4	1058505.3
BOC	15497467.0	8471715.5	187054.4	8284661.2	10977062.2	14300150.3	1197316.6
BOCM	6515935.2	3556380.4	80012.7	3476367.7	4213595.6	6033554.5	482380.7
CMBC	4817852.1	2540148.0	69728.3	2470419.7	3259804.3	4226683.0	591169.1
CMSB	4019757.5	1838080.2	43019.4	1795060.8	2469621.1	3753904.9	265852.6
BIC	4574982.2	1598973.2	45376.3	1553596.9	2283458.5	4307271.8	267710.4
CITIC	4398788.4	2198321.8	52111.5	2146210.3	2902778.9	4131697.7	267090.6
SPDB	4402585.4	2033204.0	72949.7	1960254.3	2713167.6	4129359.2	273226.2
BJB	1602481.9	679644.3	22353.0	657291.3	930408.2	1502352.1	100129.8
HZB	456386.4	196256.5	4926.9	191293.6	282756.1	429286.0	27100.4
Unit: million CNY							

As we can see from the Table 3.5, the balance sheet of the 12 selected commercial banks are shown which the unit is millions of CNY.

For the total assets we can find the assets who holds most is Industrial & commercial Bank of China as well which is around 20711607 million CNY while the assets who holds least is Bank of Hangzhou which is about 456386 million CNY.

This ranking is according to amount of operating income that each bank earns as well.

3.2.3 Items of Inputs and Outputs

This subchapter can be a very important part of this chapter, which we will describe that the items of inputs and outputs from the financial statements of the selected banks we apply to the DEA model.

For the inputs we can regard it as costs of the banks, which means if the costs are lower, it will be better for the bank. And there are two basic rules of the costs which are "*the less, the better*" and "*interest related*". Here, first one means the less costs can help make the higher profit and the second means if the items are changing, it will also

influence the profit of the bank. And in this thesis, we select the total assets, operating expense and the number of employees as the inputs items.

Total assets, which means all of funds in bank used for different forms, presented in balance sheet. It is important for one bank, total equity which means the funds owned by shareholders is also important for one bank, here we select assets instead of equity is because we choose *ROE* which is measured by net profit divided by equity, where the equity has already appeared, if we choose equity as one of our input data, there may be some repetition.

Operating expense, which is one part of income statement of bank. It can show us the investment of one bank for its basic operation and how it spends for keeping the banking business open. As we know, the business of traditional banks is not only interest business, hence, operating expense is more suitable than the interest expense.

Number of employees, reflects to how many staff one bank have which is also one of the basic information of one bank. It can also let us see how much the bank should pay for its labor cost. In addition, the amount of employees can show the scale of one bank.

For about the outputs we select the operating profit, loans, deposit and ROE as our output items.

About the loan and deposit items we choose the new deposits and new loans to the customers every year. As we know, loan and deposit are very important parts of the banks which can be very typical. Deposits is one part of liabilities in balance sheet, which present the credit of banks, loans is one part of assets in balance sheet, which is a very important tool of investing of banks.

The operating profit is the difference between the operating income and operating expense.

ROE is the net income divided by the equity which can measure the profitability of the bank.

3.3 Financial Ratios

In this subchapter we will describe the information of the banks we selected by using the financial ratios such as profitability ratios, risk ratios and other important ratios.

Financial ratios can help us to know the current situation of the banks to make sure whether the banks are health or not.

As for the financial ratios we will mainly describe two parts which are:

Profitability ratios, which can help us to assess the ability of generating profit from the investment.

Risk ratios, which can help us to measure the risk that a bank's borrower or transaction counter-party fails to fulfill the obligations specified in relevant agreements.

Then is the other ratios, such as the operating efficiency ratio, Employee productivity ratio and equity multiplier.

3.3.1 Profitability Ratios

For the profitability ratios we will mainly describe the return on assets ratios, return on equity ratio, net interest margin and the net profit margin ratio.

Return on equity (*ROE*)

Return on equity is similar to the return on investment, it is used to assess the profitability of the enterprise, can also be used in the comparison profitability of different companies in the same industry. Return on equity is calculated as:

$$ROE = \frac{EAT}{TE} = \frac{EBT}{TE} \tag{3.1}$$

In the Formula (2.1), the *EAT* means the "earnings after tax" or "net income", while the EBT means "earnings before tax". *TE* is total equity capital. Generally, 10 per cent to 20 per cent can be considered as a good level of *ROE* value for the commercial bank.

Return on assets (*ROA*)

Return on assets is the index to show you the relationship between net income and average total assets. It is used to measure how much net profit will be created by assets per unit. The formula of return on assets can be written as:

$$ROA = \frac{EAT}{TA} = \frac{EBT}{TA} \tag{3.2}$$

Here, the *TA* means total assets, and the suitable level of *ROA* depends on the types of assets which means that the assets are risky or not, and the risky assets tend to acquire a higher *ROA* while the less risky assets tend to the lower *ROA*. The good value of *ROA* usually is 1 per cent for most of commercial bank.

Net interest margin (*NIM*)

Net interest Margin is a measure of the difference between the interest income generated by banks or other financial institutions and the amount of interest paid out to their lenders (for example, deposits), relative to the amount of their (interest-earning) assets. The formula we can see as following:

$$NIM = \frac{(Interest\ Income - Interest\ Expense)}{TA} = \frac{NII}{TA} \tag{3.3}$$

Here the *NII* means net interest income. And generally, the higher of the net interest margin, the higher profitability of the bank. But if the value is too high, which represents the bank will have too much loans and too high interest rate, this situation will bring high risk to the bank. Hence, the *NIM* cannot be too high.

Net profit margin *(NPM*)

Net profit margin measures net profit (as a percentage) per one unit of revenues. It shows the expenses management of the bank which is the bank's management on the cost control and is reflect the efficiency of the pricing policy in the bank. The indicator can be written as:

$$NPM = \frac{NI}{TOR} \tag{3.4}$$

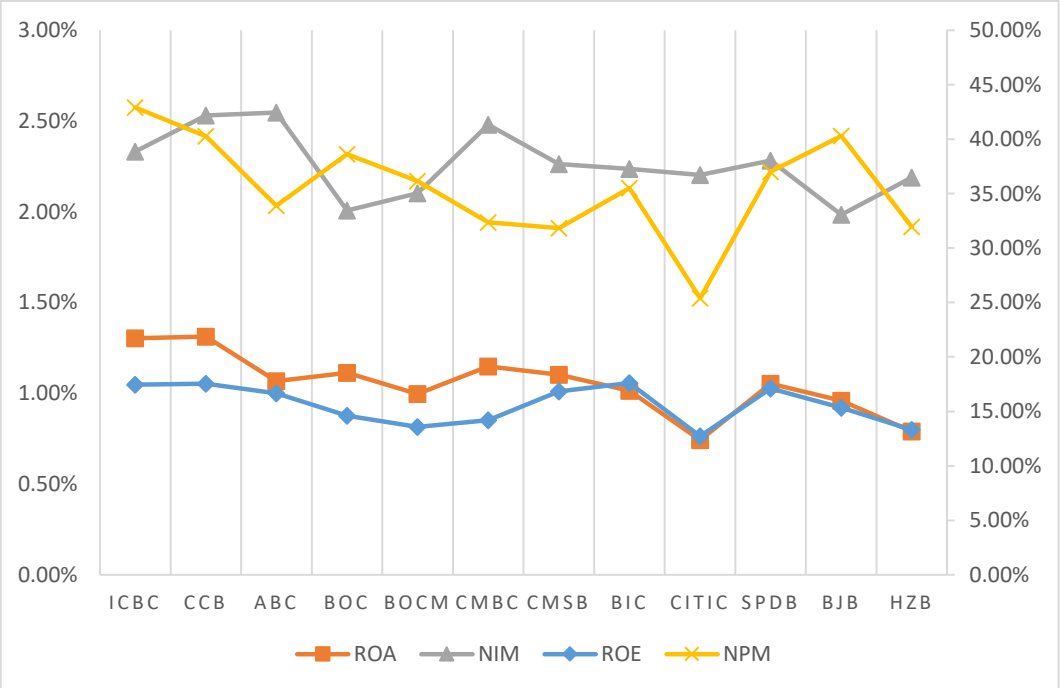
Here, the NI means the net income while the *TOR* means the total operating revenues.

By using these four formulas we can obtain the result of the indicators of the 12 selected banks which we can see from the following table.

Table 3.6 Profitability Ratios of 12 selected banks

	ROE	*ROA*	*NIM*	*NPM*
ICBC	17.45%	1.30%	2.33%	42.92%
CCB	17.55%	1.31%	2.53%	40.28%
ABC	16.65%	1.07%	2.55%	33.90%
BOC	14.61%	1.11%	2.01%	38.64%
BOCM	13.58%	1.00%	2.10%	36.15%
CMBC	14.18%	1.15%	2.48%	32.36%
CMSB	16.84%	1.10%	2.26%	31.84%
BIC	17.61%	1.01%	2.24%	35.52%
CITIC	12.73%	0.74%	2.20%	25.39%
SPDB	17.10%	1.05%	2.28%	37.01%
BJB	15.34%	0.96%	1.98%	40.31%
HZB	13.31%	0.79%	2.19%	31.94%

Chart 3.1 Profitability Ratios of 12 selected banks



From the Table 3.6 and the Chart 3.1 we can easily see the main value of profitability ratios of the 12 banks. All of the banks' *ROA* are around 1 per cent, and their *ROE* are closed to 15 per cent which we can say these value are good for these

commercial banks.

As we all know, the higher are the *NIM* and *NPM*, the better profitability the bank is, here in the chart we find all of the banks' *NIM* is around 2 per cent which can be suitable for the banks, and it means that the banks have relatively good profitability and the banks' loan are not too much and interest rate are not too high and the risk for the bank is not high. For about the *NPM* of these banks, the results are mainly around 30 per cent to 40 per cent which can also be suitable for the banks.

3.3.2 Risk Ratios

In this part we will talk about the risk ratios which includes liquidity risk ratios and credit risk ratios. And we chose three main ratios of risk ratios which are loan loss allowance ratio, loan to deposit ratio and capital adequacy ratio.

Loan loss allowance ratio (*LLA* Ratio).

Loan loss provision is an expense set aside as an allowance for uncollected loans and loan payments. This provision is used to cover a number of factors associated with potential loan losses including bad loans, customer defaults and renegotiated terms of a loan that incur lower than previously estimated payments. Loan loss provisions are an adjustment to loan loss reserves and can also be known as valuation allowances. The loan loss allowance ratio can be written as:

$$LLA\ Ratio = \frac{LLA}{Loans} \tag{3.5}$$

Generally, the level of loan loss allowance ratio between 2 per cent to 3 per cent is a good level of the commercial bank. If this indicator is too small, which means the buffer for the risk of the bank is too low, but the situation depends on the quality of the asset. The details in loan loss allowance ratio can indicate which asset is the problem for the bank.

Loan-to-deposit ratio (*LTD*)

Loan-to-deposit ratio is a commonly used statistic for assessing a bank's liquidity

by dividing the bank's total loans by its total deposits. The formula of loan to deposit ratio can be calculated as:

$$LTD = \frac{Loan}{Deposits} \tag{3.6}$$

The suitable value of the *LTD* is from 70 per cent to 80 per cent for the commercial banks generally. But if the value is too high (higher than 80 per cent), which means that there will be small buffer for the banks.

Capital adequacy ratio (*CAR*)

Capital adequacy ratio is a measure of a bank's capital. It is expressed as a percentage of a bank's risk weighted credit exposures. The formula of this indicator can be measured as:

$$CAR = \frac{Capital}{Risk\ Weighted\ Assets} \tag{3.7}$$

Generally, the indicator should be higher than 8 per cent. And the capital here includes Tier 1, Tier 2 and Tier 3 where Tier 1 includes the shareholders' equity plus some reserves which should be bigger than 50 per cent, Tier 2 includes the subordinated debt that is more than 5 years and Tier 3 include the subordinated debt that is more than 2 years. And the risk weighted assets includes credit risk, market risk and operational risk.

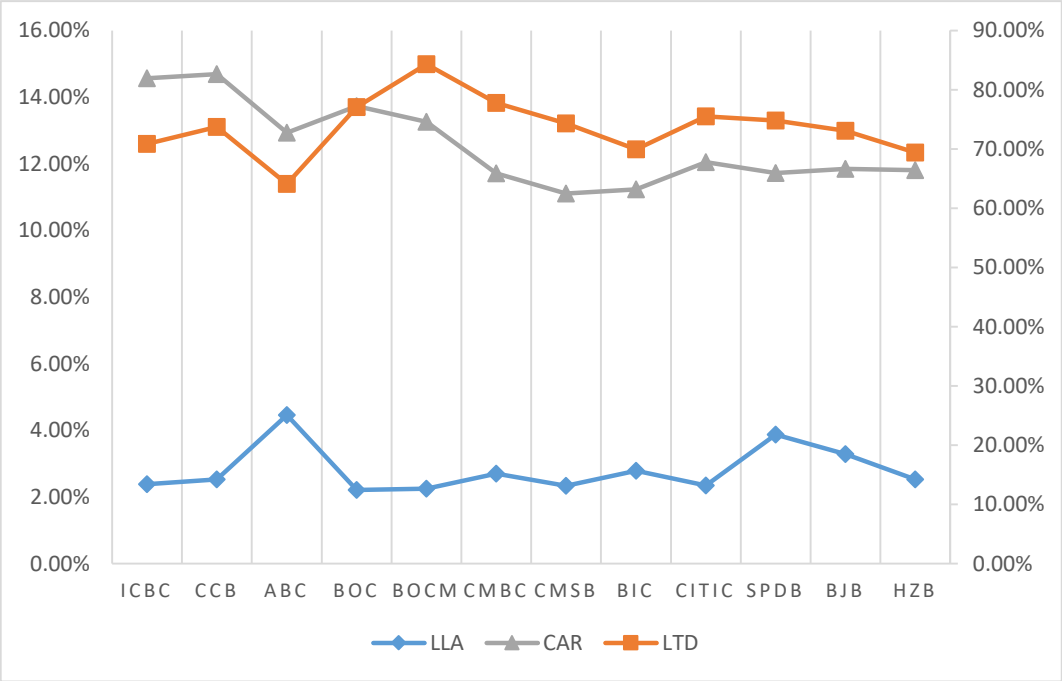
In this part we choose the total capital adequacy which the capital is equal to Tier 1 plus Tier 2 and 3.

And by using this three formulas we can measure the risk ratios of the 12 banks which results we can find from the following table and chart.

Table 3.7 Risk Ratios of 12 selected banks

	LLA	*LTD*	*CAR*
ICBC	2.38%	70.87%	14.57%
CCB	2.53%	73.72%	14.69%
ABC	4.46%	64.08%	12.93%
BOC	2.21%	77.05%	13.73%
BOCM	2.25%	84.32%	13.26%
CMBC	2.70%	77.79%	11.71%
CMSB	2.33%	74.32%	11.10%
BIC	2.78%	69.94%	11.23%
CITIC	2.35%	75.47%	12.04%
SPDB	3.87%	74.78%	11.72%
BJB	3.29%	73.05%	11.84%
HZB	2.53%	69.41%	11.81%

Chart 3.2 Risk Ratios of 12 selected banks



From the Table 3.7 and Chart 3.2 we can see the results of *LLA* ratio, *LTD* and *CAR* of each banks. For about the *LLA* ratios, we find all of the results are higher than 2 per cent which means that the buffer for the risk of the bank is enough. For the *LTD* which we find the results are mostly higher than 70 per cent and lower than 80 per cent, which we can say it is a good level of the banks. Then is about the *CAR*, all of the results

are higher than 10 per cent.

3.3.3 Efficient Ratios and Other Important Ratios

In this part we will mainly describe three ratios which are operating efficiency ratio, Employee productivity ratio and equity multiplier.

Operating Efficiency Ratio (*OER*).

An efficiency ratio can calculate the turnover of receivables, the repayment of liabilities, the quantity and usage of equity, and the general use of inventory and machinery. This ratio can also be used to track and analyze the performance of commercial and investment banks.

$$OER = \frac{Total\ Operating\ Expense}{Total\ Operating\ Revenus} \tag{3.8}$$

Generally, the small the ratio is, the better is the bank. And if the result is small, which means the utility of the bank's operating is in a good level.

Employee productivity ratio (*EPR*)

Employee productivity ratio is the ratio that can see the employee productivity level of the bank. And the indicator can be written as:

$$EPR = \frac{Net\ Operating\ Income}{Number\ of\ Full-time\ Equivialent\ Employee} \tag{3.9}$$

Equity multiplier (*EM*)

Equity multiplier is calculated by dividing a company's total asset value by total net equity, and it measures the financial leverage. The formula of this indicator can be written as:

$$EM = \frac{TA}{TE} \tag{3.16}$$

Here the *TA* means total assets while the *TE* means the total equity. The bigger is the equity multiplier, which means the proportion of the capital that the shareholders own to total assets is getting smaller, which means that the liabilities degree of the bank

is higher and the bank is more risky.

By using the three formulas above we can obtain the result which shows in the following table and chart.

Table 3.8 Other Important Ratios of 12 selected banks

	OER	*EPR*	*EM*
ICBC	34.02%	0.59	13.34
CCB	34.59%	0.60	13.34
ABC	42.18%	0.35	15.58
BOC	39.99%	0.57	13.10
BOCM	53.36%	0.66	13.61
CMBC	36.28%	0.76	12.41
CMSB	57.30%	0.76	15.27
BIC	54.68%	0.94	17.32
CITIC	36.34%	0.62	17.14
SPDB	51.57%	1.04	16.23
BJB	50.38%	1.32	16.00
HZB	60.82%	0.68	16.84

Chart 3.3 Other Important Ratios of 12 selected banks

From the Table 3.8 and Chart 3.3 we can find the result of these three indicators of each banks. As about the OER the results are totally higher than 33 per cent, but the

smaller the better, the ratios of BIC, CMSB and HZB are a little bit high. And for about the EPR which show us that how much profit earns by each full-time employees, and the highest value an employee earns is SPDB while the lowest one is ABC. And then about the EM which we can see that most banks' assets are much higher than the equity. The higher is the EM ratios which means that the liabilities degree of the bank is higher and the bank is more risky.

3.4 Summary

In this chapter we make some basic information of our selected banks for our thesis.

Firstly, we describe the basic information of Chinese banking system and make some simple SWOT analysis of it.

Then, we talk about the selected banks' financial statements such as the income statements and the balance sheet, and by comparing the amount of operating incomes we divided the 12 selected banks into 2 groups, the group of making incomes higher than 400000 million CNY and the group of making incomes lower than 400000 million CNY.

Finally we describe the financial analysis principal such as the profitability ratios, risk ratios and other important ratios.

4. Application of Selected Models to Evaluate the Banks' Efficiency

This chapter is about the application of DEA models for selected banks, which is the main chapter in our thesis. During this chapter we will use the CCR model and SBM model to evaluate the 12 banks we selected. Firstly, we will make some financial analysis for these banks from the year 2011 to 2015.

We suppose the weights of each year are as following:

Table 4.1 Weights of the years from 2011 to 2015

	2011	2012	2013	2014	2015	total
weight	5%	7.50%	12.50%	25%	50%	100%

4.1 Financial Analysis of Selected Banks

We will now use the results of financial analysis we measured in the chapter 2 to compare with two groups of these twelve banks we selected.

The financial statements we choose are from 2011 to 2015 which are found from banks' annual reports and we use the weight above as well.

We will also make the average and variance value of each group (operating income earned higher than 400000 million CNY and operating income earned lower than 400000 million CNY).

4.1.1 Profitability Ratios of Selected Banks

In this subchapter we mainly analyze the banks' profitability the results are shown as follows.

Table 4.2 Profitability Ratios of Selected Banks

	ROE	*ROA*	*NIM*	*NPM*		*ROE*	*ROA*	*NIM*	*NPM*
ICBC	17.45%	1.30%	2.33%	42.92%	BOCM	13.58%	1.00%	2.10%	36.15%
CCB	17.55%	1.31%	2.53%	40.28%	CMBC	14.18%	1.15%	2.48%	32.36%
ABC	16.65%	1.07%	2.55%	33.90%	CMSB	16.84%	1.10%	2.26%	31.84%
BOC	14.61%	1.11%	2.01%	38.64%	BIC	17.61%	1.01%	2.24%	35.52%
					CITIC	12.73%	0.74%	2.20%	25.39%
					SPDB	17.10%	1.05%	2.28%	37.01%
					BJB	15.34%	0.96%	1.98%	40.31%
					HZB	13.31%	0.79%	2.19%	31.94%
variance	0.186	0.002	0.006	1.436	variance	0.362	0.002	0.002	2.017
std.	0.014	0.001	0.003	0.038	std.	0.019	0.001	0.001	0.045
average	16.57%	1.20%	2.35%	38.93%	average	15.09%	0.98%	2.22%	33.81%
Unit of variance: 10^{-3}									

From the Table 4.2, in banks in the left list are the banks who earns more than 400000 million CNY, while the banks in the right list are the banks who earns lower than 400000 million CNY.

Here we say that the left list is list A and the right list is list B.

By comparing each value of these banks we find that *ROE* of list A is almost higher than 16.6 per cent while it in list B is from 13 per cent to 17.6 per cent, we can say that the banks' *ROE* in list A is relatively higher than the Banks' in list B. As same as the *ROA*, which of the four banks in list A is also relatively higher than it in list B and the all of the value are close to 1 per cent. For about these result we can say that the large banks have relatively stronger profitability than medium and small banks.

As for the ratio of *NIM*, all banks in list A are higher than it in list B. and for about the *NPM* ratio, we can find that the banks in list A is mostly higher than 40 per cent while it in the list B is totally lower than 40 per cent except the Bank of Beijing.

For the average of each ratio we can find that totally all of them in list A are higher than them in list B. for this we can say that the profitability of the banks who earns higher than 400000 million CNY each year are relatively better than the profitability of the banks who earns lower than 400000 million CNY.

Some reasons we can say because the most banks in list B is relative new banks than in the list A, for example the SPDB bank was founded in the year of 1992 and the CMSB bank was founded in the year of 1996. Also these banks have more operations than the other relative small commercial banks. But in fact, from these data we can see that the value of all ratios are relatively stable while the banks CITIC performs worst whose ratio of *ROE* is only 12.37 per cent and ratio of *NPM* is also the lowest which is around 25.39 per cent.

For measuring the variance of each ratios, we know that all banks' profitability are relative stable during these years.

From the table we can find the profitability ratios of BJB and HZB are very different to each other. However, in fact, both of them are municipal commercial banks. Hence, we will now use their financial statements during 2015 to compare them.

Therefore, following we will compare them in detail which we can see from the Table 4.3.

Table 4.3 Comparison of BJB & HZB

	BJB		HZB	
	2015	weight	2015	weight
net interest income	35785	31784.7	11037	9986.5
noninterest income	8296	6321.2	1367	1303.9
operating income	44081	38105.9	12404	11290.3
operating expense	23045	19197.2	7907	6866.8
net profit	16883	15359.7	3705	3606.5
total assets	1844909	1602481.9	545314	456386.4
total loans	775390	679644.3	215256	196256.5
loan loss allowance	27473	22353.0	5682	4962.9
net loans	747917	657291.3	209574	191293.6
deposit	1022300	930408.2	312046	282756.1
total liabilities	1728095	1502352.1	513420	429286.0
total equity	116814	100129.8	31894	27100.4
number of employees	13776	11623.8	5763	5315.5
Unit: million CNY (except number of employees)				

The lists which named “weight” means the weighted average value from 2011 to 2015, the weight of each year we have mentioned at the beginning of this chapter. And the list with “2015” is the value from 2015’s financial statements of two banks.

As we can see from the Table 4.3 we find that BJB has much higher value of assets and equities than HZB has, as well as their operating income. For the value of net profit of BJB is even fivefold higher than it of HZB which means that the BJB earns much more than HZB earns. As we can see, HZB only has 5763 employees while BJB has number of employees higher than 13770. The reason for this situation we can say that is because Bank of Beijing is a municipal commercial bank of Beijing which is Chinese capital city, but Bank of Hangzhou is only a municipal commercial bank in Hangzhou which is just the provincial capital in Zhejiang province. BJB may have larger scale than HZB has.

According to the profitability ratios we calculated we find the four large banks have relatively stronger profitability than the medium and small banks, some reasons we think can be that because these four large banks are stated owned, and they have government support, which means they are lower risky and more consumers are willing to invest their rather than other banks. These make them have more deposits.

4.1.2 Risk Ratios of Selected Banks

Then we talk about the risk ratios of each banks, here we use the loan loss allowance ratio, loan to deposit ratio and capital adequacy ratio. Following is the result which we measured.

Table 4.4 Risk Ratios of Selected Banks

	LLA	*LTD*	*CAR*		*LLA*	*LTD*	*CAR*
ICBC	2.38%	70.87%	14.57%	BOCM	2.25%	84.32%	13.26%
CCB	2.53%	73.72%	14.69%	CMBC	2.70%	77.79%	11.71%
ABC	4.46%	64.08%	12.93%	CMSB	2.33%	74.32%	11.10%
BOC	2.21%	77.05%	13.73%	BIC	2.78%	69.94%	11.23%
				CITIC	2.35%	75.47%	12.04%
				SPDB	3.87%	74.78%	11.72%
				BJB	3.29%	73.05%	11.84%
				HZB	2.53%	69.41%	11.81%
variance	0.110	3.042	0.067	variance	0.031	2.230	0.043
std.	0.011	0.055	0.008	std.	0.006	0.047	0.007
average	2.89%	71.43%	13.98%	average	2.76%	74.88%	11.84%
							Unit of variance: 10^{-3}

LLA is an expense set aside as an allowance for uncollected loans and loan payments. If the uncollectable assets in portfolio's estimated risk is higher, then the LLA reserve should be higher as well. From the Table 4.4 the value of ratio of *LLA* of each bank is similar, while the average value of it in list A is a little bit higher than it in list B. Among these, the highest one in list A is ABC bank which is 4.46 per cent while the highest one list B is SPDB bank is 3.87 per cent. And in fact, the optimal value of *LLA* ratio is between 2 per cent and 3 per cent to commercial banks, if the value it too low which means the buffer for the risk of bank is too low, but this is depending on the situation of equity. Fortunately, all of banks' *LLA* ratio is higher than 2 per cent. But the ratios of ABC, BJB and SPDB are higher than 3 per cent which means that their structure of loan is not perfect enough or their attitude to credit risk is even conservative.

And for the *LTD* ratio we find most banks' is higher than 70 per cent. In fact, the optimal value of this ratio is from 70 per cent to 80 per cent, if it is too high, which means there is small buffer. And we see from the Table 4.4 we find BOCM bank's ratio is even higher than 80 per cent and ABC, HZB and BIC's are even lower than 70 per cent. Hence, we will now choose three of them to compare these in detail.

Table 4.5 Comparing of LTD Ratios of BOCM, ABC & BIC

		2011	2012	2013	2014	2015	WAV
BOCM	total loans	2618115	3014970	3339673	3508683	3809444	3556380
	deposit	3288232	3728412	4157833	4029668	4484814	4213596
	LTD	79.62%	80.86%	80.32%	87.07%	84.94%	84.32%
ABC	total loans	5639928	6433399	7224713	8098067	8909918	8147066
	deposit	9622026	10862935	11811411	12533397	13538360	12674777
	LTD	58.61%	59.22%	61.17%	64.61%	65.81%	64.08%
BIC	total loans	983254	1229165	1357057	1593148	1779408	1598973
	deposit	1345279	1813266	2170345	2267780	2483923	2283459
	LTD	73.09%	67.79%	62.53%	70.25%	71.64%	69.94%
Unit: million CNY (except LTD ratio)							

From the Table 4.5 we can find that the ratio of *LTD* of BIC is almost stable while in the year of 2013 it was 62.53 per cent which is low and then lead to the low final weighted average value. And for the ABC bank we can find the obvious tendency of *LTD* ratio which is increasing each year, this can be a good change of the bank. Then we focus on the BOCM bank we find during these five years, *LTD* ratio of the bank is mostly around 80 per cent, in the year of 2014 it is even higher than 87 per cent, fortunately in 2015 there is a decreasing trend of it.

Here the *CAR* means the capital adequacy ratio, which is a measure of amount of a bank's core capital expressed as a percentage of its risk-weighted assets and here the capital we use is "Tier1 + Tier2".

It is easy for us to find from Table 4.4 that the *CAR* ratios of all banks are higher than 10 per cent which can be good situation. Among them, the highest one is CCB bank which is around 14.69 per cent and the lowest one is CMSB is 11.10 per cent. And weighted average value of the banks in list A is 14.06 per cent which is around 2 per cent higher than the weighted average value of the banks in list B. the four large banks have higher CAR than other remaining banks, although in fact their value is not very high as well. In fact, because of the structure of Chinese banking system, deposit are the main source of financing, in order to keep profitability and continue to open, banks choose to make more loans which leads to the high risky assets, then the banks need

more deposits. As we talk in the profitability ratios, the four large banks have more deposit than other remaining banks, it is why they have higher CAR.

4.1.3 Efficient Ratios and Other Ratio of Selected Banks

Then we will describe the efficient ratios and other ratios of each banks, here we choose operating efficiency ratio, employee productivity ratio and equity multiplier ratio. The result is shown as following table.

Table 4.6 Efficient Ratios and Other Ratio of Selected Banks

	OER	*EPR*	*EM*		*OER*	*EPR*	*EM*
ICBC	34.02%	0.59	13.34	BOCM	53.36%	0.66	13.61
CCB	34.59%	0.60	13.34	CMBC	36.28%	0.76	12.41
ABC	42.18%	0.35	15.58	CMSB	57.30%	0.76	15.27
BOC	39.99%	0.57	13.10	BIC	54.68%	0.94	17.32
				CITIC	36.34%	0.62	17.14
				SPDB	51.57%	1.04	16.23
				BJB	50.38%	1.32	16.00
				HZB	60.82%	0.68	16.84
variance	0.002	0.014	1.361	variance	0.008	0.057	3.097
std.	0.040	0.119	1.167	std.	0.091	0.239	1.760
average	37.70%	52.93%	13.84	average	50.09%	84.71%	15.60

As we know that the value of *OER* is obtain by total operating expense divided by total operating revenues, hence, the lower the better. From the Table 4.6 we can see that most banks' value of *OER* are lower than 40 per cent while there are five banks whose value of *OER* are higher than 50 per cent which means that the operating expense have a large proportion of total operating revenues of these banks, especially the Bank of Hangzhou's proportion of operating expense in operating income is even higher than 60 per cent.

And the employee cost can be a big part of operating expenses, which we can say that, if the value of *OER* is higher and the value of *EPR* will be lower. And by the increasing of number of employee, the pressure of expenses will be higher to banks. And from the Table 4 we find that BJB bank has higher *EPR* than other, this is because

it has fewer number of employees.

And for about the *EM*, which is obtained by total assets divided by total equity. The bigger is the equity multiplier, which means the proportion of the capital that the shareholders own to total assets is getting smaller, which means that the liabilities degree of the bank is higher and the bank is more risky. Here from the table we find CMSB, BIC, CITIC, PDB, BJB and HZB banks are more risky than others whose *EM* are higher than 15. In addition, the state owned commercial banks are lower risky than private commercial banks.

4.1.4 Summary

In this subchapter, we measure and analyze the financial ratios in detail of these twelve banks we selected, and they are ranked by the amount of operating income each bank earns during last five years from 2011 to 2015.

For the financial ratios we mainly analyze the profitability ratios, risk ratios, efficient ratios and equity multiplier.

By this analysis, we find that all banks' performances are relative stable during these years, and the profitability of the four banks whose operating income is more than 400000 million CNY is better than other seven banks. And we also find that the operating expense of eight banks whose operating income is lower than 400000 million CNY has larger proportion of operating revenues than it in the other four banks.

According to the profitability ratios we calculated we find the four large banks have relatively stronger profitability than the medium and small banks, some reasons we think can be that because these four large banks are stated owned, and they have government support, which means they are lower risky and more consumers are willing to invest their rather than other banks. These make them have more deposits.

According to the risk ratios we find the state owned banks are lower risky than the private banks, because state owned banks have government support and which help them to reduce the risk.

However, in fact, the result cannot be so simply like this, it is one-sided.

The main topic of our thesis is “efficiency”, which means we should find out how efficiency each bank is. A bank who is efficient should have maximum profitability, have minimum risk exposure and have the effective expense management.

Hence, in order to obtain more clear result, next we will apply the DEA model we describe in chapter 2 to analyze the twelve banks we selected.

4.2 Efficiency Analysis by DEA Models

In this subchapter we will use DEA models to analyze the efficiency of the banks we selected. And the main model we use are CCR model and SBM model. Firstly we will talk about the inputs and outputs we choose.

4.2.1 Items of Inputs and Outputs

In this part we describe the items we choose for inputs and output.

For about inputs we select three items, which are operating expenses, total assets and number of employees.

For about outputs we choose four items, which are operating incomes, new loans, new deposits and *ROE* ratio.

Total assets, which means all of funds in bank used for different forms, presented in balance sheet. It is important for one bank.

Operating expense, which is one part of income statement of bank. It can show us the investment of one bank for its basic operation and how it spends for keeping the banking business open.

Number of employees, reflects to how many staff one bank have which is also one of the basic information of one bank. It can also let us see how much the bank should pay for its labor cost. In addition, the amount of employees can show the scale of one bank.

About the loan and deposit items we choose the new deposits and new loans to the customers every year. As we know, loan and deposit are very important parts of the banks which can be very typical. Deposits is one part of liabilities in balance sheet,

which present the credit of banks, loans is one part of assets in balance sheet, which is a very important tool of investing of banks.

The operating profit is the difference between the operating income and operating expense.

ROE is the net income divided by the equity which can measure the profitability of the bank.

The data of these items are shown as following table.

Table 4.7 Data of Items of Inputs & Outputs

	Inputs Items			**Outputs Items**			
	(I)Operating Expenses	(I)Assets	(I)Number of Employees	(O)Operating Incomes	(O)New Loans	(O)New Deposits	(O)*ROE*
ICBC	213329.7	20711606.9	456475.9	628702.7	995421.2	878262.3	17.45%
CCB	189991.1	16943222.8	366366.5	551081.1	985858.2	811109.5	17.55%
ABC	215286.0	16286701.8	491761.8	510544.0	825284.6	931311.7	16.65%
BOC	177656.4	15497467.0	299391.9	445854.7	717444.0	824950.1	14.61%
BOCM	96077.0	6515935.2	97072.7	179216.7	282044.4	303242.1	13.58%
CMBC	61544.4	4817852.1	72100.7	172791.7	301203.9	335847.4	14.18%
CMSB	79995.4	4019757.5	57268.7	138293.1	221835.1	281067.3	16.84%
BIC	73280.4	4574982.2	48692.3	131619.8	193028.3	222789.8	17.61%
CITIC	46096.9	4398788.4	51743.1	127666.8	221835.1	281067.3	12.73%
SPDB	65908.5	4402585.4	44244.4	126218.7	226889.3	222789.8	17.10%
BJB	19197.2	1602481.9	11623.8	38105.9	93728.4	97205.9	15.34%
HZB	6866.8	456386.4	5315.5	11290.3	20648.8	31742.5	13.31%
Units: million CNY (except number of employees & ROE)							

All these data in Table 4.7 are measured by using data during 2011 to 2015 and the weight we mentioned at the beginning of this chapter.

Here the twelve banks are ranked by their amount of operating incomes. And all banks' unit is million CNY.

Finally we obtain the data which shown in Table 4.7.

There are some connection with these seven items, if one bank has lower operating expense, its net profit will be higher and then result of *ROE* will be higher as well. If one bank has higher deposit which mean it has higher liabilities and then the total assets of the bank will be higher, because assets equal to liabilities plus equity. Higher

operating income will also lead to the higher value of *ROE*, and the larger loans one bank has, the higher assets it will be. The number of employees can show the scale of one bank, on large bank will have bigger amount of employees than the medium or small banks. For example, ICBC has larger number of employees than the HZB has, obviously the scale of ICBC is larger than HZB as well.

An efficient bank means the bank has maximum profitability, have minimum risk exposure and have the effective expense management. If the operating expense of the bank is increasing or the operating incomes of the bank is decreasing will both reduce its efficiency level. In addition, changes of each input or output items will influence the efficiency level of banks.

4.2.2 Application of CCR Model

In this part we will make the application of CCR model. We use the software which we have introduced in Chapter 2, *DEA-Solver-LV*. By this convenience software, once we put our data into we can obtain the result immediately.

Hence, we are able to analyze the efficiency of selected banks by the result we obtain.

Firstly, we will put the results of efficiency of each bank by using the CCR model.

We choose the "*CCR-I*" in the software as our CCR efficiency analysis and then we can find the result in our worksheets.

Table 4.8 CCR – Input Excesses of Selected Banks

DMU	Score	Excess (s^-)					
		Operating Expenses		Assets		Number of Employees	
		Volume	α_{1n}	Volume	α_{2n}	Volume	α_{3n}
ICBC	1	0	0.00%	0	0.00%	0	0.00%
CCB	1	0	0.00%	0	0.00%	0	0.00%
ABC	0.87	6324.4	15.54%	0	12.60%	216784.4	56.68%
BOC	0.88	0	11.51%	0	11.51%	41993.5	25.54%
BOCM	0.77	9723.4	33.22%	0	23.10%	0	23.10%
CMBC	1	0	0.00%	0	0.00%	0	0.00%
CMSB	1	0	0.00%	0	0.00%	0	0.00%
BIC	0.97	6503.7	11.39%	0	2.51%	0	2.51%
CITIC	1	0	0.00%	0	0.00%	0	0.00%
SPDB	1	0	0.00%	0	0.00%	0	0.00%
BJB	1	0	0.00%	0	0.00%	0	0.00%
HZB	1	0	0.00%	0	0.00%	0	0.00%
Unit of Volume: million CNY							

Here, the list of "Volume" means the true value of slacks of each bank. "Score" refers to the efficient ratio of each bank. "α_{mn}" means the percentage changes of each input item if banks pay attention to solve current condition and achieve efficiency. And we use the Formula (2.14) to measure and obtain results.

From the table above, we can see the input excesses situation of each bank, the banks who obtain the score $\theta^* = 1$ means that the bank has no input excess, here we select 12 banks to analyze, and four of them are in input excesses, they are ABC, BOC, BOCM and BIC.

We find the most serious problem is number of employees, especially in large banks, ABC bank's excess of number of employees is even higher than 50 per cent which means it should cut half of staff. This situation if medium and small banks is better, which the highest one is around 23 per cent. The reason we think it that, because the large banks have bigger scale and they need more staff, however they hire too many, and many of staff's work performance does not accord with their income, like they obtain such amount of income but they work not enough which leads to the wasting

expense of wages and salaries, and then the operating expenses become higher. As we can see, if one bank has excess problem of number of employees, it will also has the excess problem of operating expenses.

And from the table we can also obtain the average sore of all banks is 0.959.

Table 4.9 CCR – Output Shortfalls of Selected Banks

DMU	Shortfall (s^+)							
	Operating Incomes		New Loans		New Deposits		*ROE*	
	Volume	β_{1n}	Volume	β_{2n}	Volume	β_{3n}	Volume	β_{4n}
ICBC	0	0.00%	0	0.00%	0	0.00%	0	0.00%
CCB	0	0.00%	0	0.00%	0	0.00%	0	0.00%
ABC	0	0.00%	64676.5	7.84%	61009.8	6.55%	0.253	151.94%
BOC	0	0.00%	39470.3	5.50%	0	0.00%	0.17	116.34%
BOCM	0	0.00%	30466.9	10.80%	44740.7	14.75%	0.012	8.83%
CMBC	0	0.00%	0	0.00%	0	0.00%	0	0.00%
CMSB	0	0.00%	0	0.00%	0	0.00%	0	0.00%
BIC	0	0.00%	44763.3	23.19%	16406.9	7.36%	0	0.00%
CITIC	0	0.00%	0	0.00%	0	0.00%	0	0.00%
SPDB	0	0.00%	0	0.00%	0	0.00%	0	0.00%
BJB	0	0.00%	0	0.00%	0	0.00%	0	0.00%
HZB	0	0.00%	0	0.00%	0	0.00%	0	0.00%
Unit of Volume: million CNY (except ROE)								

Here, except the *ROE* item all items use the unit of million CNY. "β_{sn}" refers to the percentage change of each output item if banks want to solve the output shortfall to achieve the efficiency. And because ROE itself is the ratio which is obtain by net profit divided by total equity, which is expressed by percentage, if there approaches a output shortfall in *ROE*, the value can be larger than the original value of *ROE*, this is why there is 100 per cent exists in β_{sn}.

From the Table 4.9 we can easily find which bank is in output shortfall and which bank is not. For the items of operating income, no bank has output shortfall, in new loans item, four banks have output shortfalls which are ABC, BOC, BOCM and BIC. And in the items of new deposit, there are three banks have the output shortfalls, they

are ABC, BOCM and BIC, while in the ROE item changes to ABC, BOC and BOCM which has three banks as well.

Also, we can see the banks who obtain the score $\theta^* = 1$ means that the bank has no output shortfalls.

Table 4.10 CCR – Weights of input Items and Output Items

DMU	V_1 Operating Expense	V_2 Assets	V_3 Number of Employees	U_1 Operating Incomes	U_2 New Loans	U_3 New Deposits	U_4 *ROE*
ICBC	1	0	0	98.09%	0	0	1.91%
CCB	53.49%	46.51%	0	0	1	0	0
ABC	0	1	0	87.40%	0	0	0
BOC	97.11%	2.89%	0	76.01%	0	12.48%	0
BOCM	0	39.03%	60.97%	76.90%	0	0	0
CMBC	0.55%	99.45%	0	0	0	1	0
CMSB	0	1	0	10.34%	0	89.10%	0.57%
BIC	0	49.32%	50.68%	95.51%	0	0	1.98%
CITIC	93.17%	0	6.83%	94.00%	0	0	6.00%
SPDB	0	48.69%	51.31%	1	0	0	0
BJB	0	75.80%	24.20%	0	0	1	0
HZB	0	51.10%	48.90%	76.98%	0	0	23.02%

Here V_n and U_n means the weight of each item of input and output for each bank.

From the Table 4.10 we can clearly see the weight of each item for every bank. One of the output item, *ROE* has the lowest weight value for each bank. The item of output, new deposit has almost zero weight for all banks except the CCB bank who has 1 of it.

The lower is input and higher is output, the better will the bank be. Hence, if one item's weight value is low means the bank does not manage it well and there is an inefficient, on the contrary, if one item's weight value is high means the bank manages it well and there is an efficient.

After using the software we find there are four banks that are inefficient, which are ABC, BOC, BOCM and BIC. Now we put there reference in following table.

Table 4.11 CCR – Reference Set of Inefficient Banks

Inefficient Banks	Scores	Reference (λ^*)					
ABC	0.874	CMBC	2.955				
BOC	0.885	ICBC	0.196	CMBC	1.287	CITIC	0.784
BOCM	0.769	CMBC	1.026	SPDB	0.016		
BIC	0.975	CMBC	0.13	SPDB	0.836	BJB	0.096

In Table 4.11 shows the reference set of inefficient banks.

The banks who obtain the scores $\theta^* = 1$ are efficient are there are no input excesses and output shortfalls of them.

After putting the result we will make the interpretation and improvement of the banks we selected.

By analyzing the data we know that there are four inefficient banks, and half of them are from the group who earns operating income more than 400000 million CNY and another two are from the other group. Hence, we can say the banks in list B have better efficient situation than banks in list A, which can also say as “the performance of small and medium banks is better than the performance of large banks”. Almost all banks in list B are efficient except BOCM and BIC, whose score of efficient are 0.77 and 0.97.

We know the average score of efficient is 0.959.

By analyzing Table 4.8 and 4.9 we can find the serious problem of inefficient banks is item of “number of employees”. Especially the ABC bank, which we see the ratio is 56.68 per cent even higher than 50 per cent, it means there is a half number of employees in ABC has been wasted, or it needs to fire them. BOC and BOCM also have this problem but not serious like ABC, the ratio of them are 25.54 per cent and 23.10 per cent, which means they waste one-fourth of their employees.

The biggest problem of BOCM is operating expenses whose ratio is about 33.22 per cent, which means that this bank has too much cost, it should reduce cost to make higher profits.

It seems that the biggest problem for BIC is new loans which ratio is around 23.19

per cent.

As to item of ROE, the shortfall of *ROE* can also be a problem for each bank. Because it is obtain from net profit divided by equity.

The four inefficient banks. Which means in the *ROE* shortfall, ABC is in the worst situation and in fact, BOC is similar.

For these total seven items, ABC almost has problem with all of them except the operating income, however, in fact, no bank has problem with it. Hence, ABC should pay more attention to solve the problems in order to make itself be an efficient banks. And other three banks should adjust themselves as well.

From the Table 4.10, which shows us each input and output under the optimal situation. We find the BOC has the best management of operating expenses, CMBC manages the assets better than other banks, BOCM manages its number of employees best, managing of operating income of BIC bank is the best, CMSB manages its new deposits better than other banks and the one who has best *ROE* is HZB.

As we have said, there are four banks that are inefficient, which we put into Table 4.11, this table shows the reference set of these banks. And here if $\lambda^* = 0$ which means the bank is total efficient, if $\lambda^* = 1$, is the efficient banks, reference banks are themselves. And we can notice that the four inefficient banks are satisfied by $\sum \lambda^* > 1$. Which means these four banks are decreasing returns-to-scale, and other all efficient banks we regard them as the constant return-to-scale.

Now we try to adjust and improve the efficiency of four inefficient banks and the results are shown as following.

Table 4.12 CCR – Projection of Four Inefficient Banks

		Operating Expense	Assets	Number of Employees	Operating Incomes	New Loans	New Deposits	*ROE*
ABC	Data	215286.0	16286701.8	491761.8	510544.0	825284.6	931311.7	0.17
	Projection	208961.7	16286701.8	274977.4	510544.0	889961.1	992321.5	0.42
0.874	Diff.	-6324.4	0.0	-216784.4	0.0	64676.5	61009.8	-0.25
	(%)	-2.94	0.00	-44.08	0.00	7.84	6.55	151.67
BOC	Data	177656.4	15497467.0	299391.9	445854.7	717444.0	824950.1	0.15
	Projection	177656.4	15497467.0	257398.3	445854.7	756914.3	824950.1	0.32
0.885	Diff.	0.0	0.0	-41993.5	0.0	39470.3	0.0	-0.2
	(%)	0.00	0.00	-14.03	0.00	5.50	0.00	116.66
BOCM	Data	96077.0	6515935.2	97072.7	179216.7	282044.4	303242.1	0.14
	Projection	86353.5	6515935.2	97072.7	179216.7	312511.3	347982.8	0.15
0.769	Diff.	-9723.4	0.0	0.0	0.0	30466.9	44740.7	0.0
	(%)	-10.12	0.00	0.00	0.00	10.80	14.75	9.08
BIC	Data	73280.4	4574982.2	48692.3	131619.8	193028.3	222789.8	0.18
	Projection	66776.7	4574982.2	48692.3	131619.8	237791.7	239196.6	0.18
0.975	Diff.	-6503.7	0.0	0.0	0.0	44763.3	16406.9	0.0
	(%)	-8.88	0.00	0.00	0.00	23.19	7.36	0.00
								Unit: million CNY

Here in the table, the "*Data*" lines are the weighted mean value from 2011 to 2015 of original data for each item of banks. The "*Projection*" lines refer to the developed

number of each item in the CCR-efficient. The "*Diff.*" is the difference between original data and projection data. "*(%)*" means the elimination and the adjunction to the inputs and outputs of each selected bank.

In fact, even we obtain the result directly from *DEA-Solver-LV*, we still should know how we get the projection data. We will now choose one bank, ABC to measure it and also verify the result in Table 4.12.

From the tables above, we now obtain the data of ABC as following:

Here we suppose to sign each bank we selected by the ranking of them, for example, ICBC bank can be written as "$ICBC_1$" of directly sign it as "1st" or "1".

Score of $\theta^* = 0.874$;

$\lambda^*_6 = 2.955$, and other $\lambda^*_j = 0$; and the reference set for ABC is: $E_3 = \{CMBC_6\}$

The input excesses and output shortfalls are: $s_1^- = 6324.4$ (operating expenses), $s_3^- = 216784.4$ (number of employees), $s_2^+ = 64676.5$ (new loans), $s_3^+ = 61009.8$ (new deposits), $s_4^+ = 0.253$ (ratio of ROE);

By using the data we obtain we can calculate the projection of it by using the Formula (2.13).

$$\widehat{x_o} \leftarrow \theta^* x_o - s^{-*}$$

$$\widehat{y_o} \leftarrow y_o + s^{+*}$$

Therefore,

$$\widehat{x_1} \leftarrow \theta^* x_1 - s_1^- = 0.874 * 215286.0 - 6324.4 = 208961.7$$

$$\widehat{x_3} \leftarrow \theta^* x_3 - s_3^- = 0.874 * 491761.8 - 216784.4$$

$$\widehat{y_1} \leftarrow y_1 + s_1^+ = 510544.0 + 0 = 510544.0$$

$$\widehat{y_2} \leftarrow y_2 + s_2^+ = 825284.6 + 64676.5 = 889961.1$$

$$\widehat{y_3} \leftarrow y_3 + s_3^+ = 931311.7 + 61009.8 = 992321.5$$

$$\widehat{y_4} \leftarrow y_4 + s_4^+ = 0.17 + 0.25 = 0.42$$

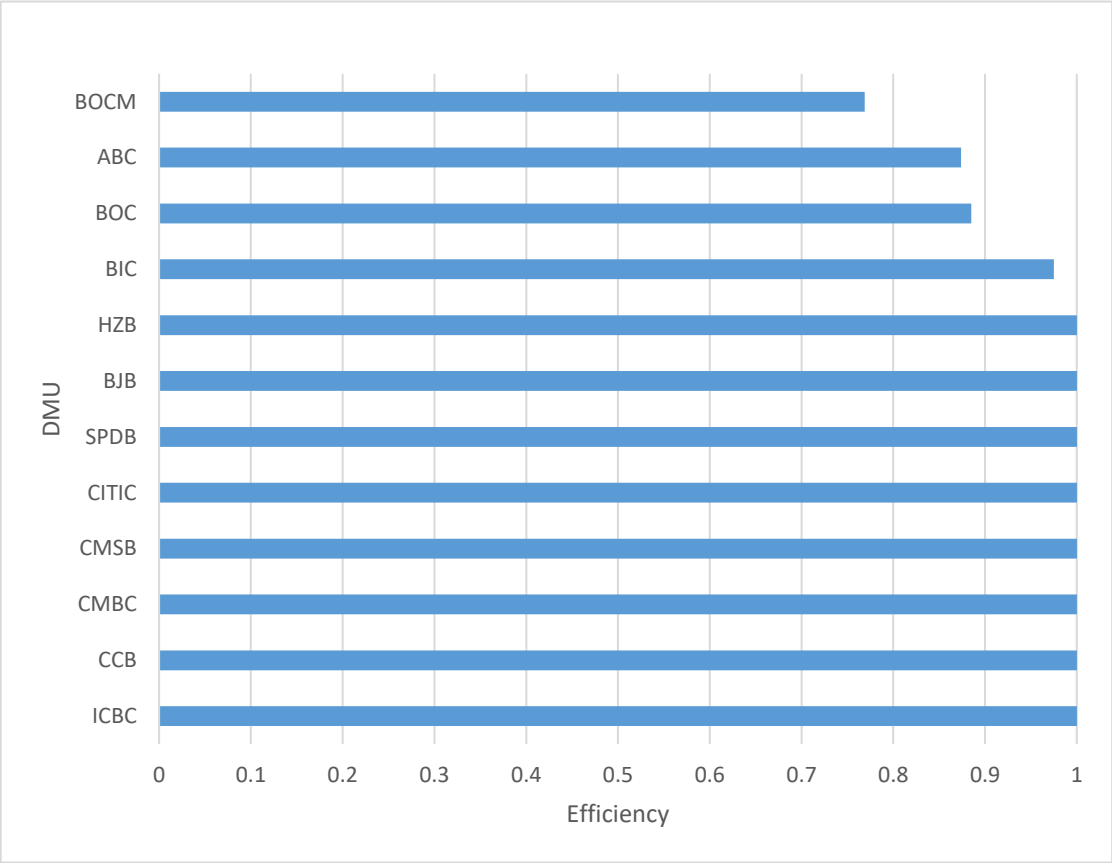
Obviously, the projection value we measured is same as which measured by the model we applying. Then, the remaining three banks projection value we can directly found in the Table 4.12.

CCR – Summary

By applying the CCR model which is the one of the typical radial models in DEA models

We find that there are four banks that are inefficient. And other are efficient which means they do not have any input excesses or output shortfalls.

Chart 4.1 CCR –Ranking of Each Banks According to their Score



From the Chart 4.1, the BOCM bank can be found is the bank whose performance is worst, ABC and BOC is similar, then is HZB.

We find that the medium and small banks' efficiency performance is better than large banks. Because there are half inefficient banks are large banks who earn operating income more than 400000 million CNY per year.

In order to solve the inefficient situation, the four banks need to improve their input excess and output shortfalls. Hence we use the "*CCR-I*" in *DEA-Solver-LV*

(version8) to obtain the result of projection data for them.

The biggest problem of banks is the excess of number of employees, which also leads to the excess of operating expenses. For these problems, banks need to cut some amount of employees, such as the employees whose work efficiency is low or they can reduce the wages and salaries of staff in order to make lower operating expenses.

4.2.3 Application of SBM Model

The CCR model we applied in previous part is a typical radial model, it reflects the proportional maximum input or outputs reduction rate which is common to all inputs or outputs.

However, in fact, not all inputs or outputs behave in the proportional way. In many situation, we can find many remaining non-redial slacks. Hence, in this part we will apply the non-redial measurement model which called Slacks-Based Measure of Efficiency (SBM) for our selected banks.

SBM model is a measurement that based on CCR model and there are some improvement for it. The ranging scalar measurement of SBM model is [0, 1]. And items of inputs and outputs in our thesis have no radial relationship, hence, the SBM model can be useful.

In this part, we will use the software – *DEA-Solver-LV* (version 8) as well. And from the results we obtain, we can analyze the results and find the inefficient banks and then improve them.

The processes of SBM model is similar to the CCR model. We choose our items of inputs and outputs, put them into Excel and them choose the "*SBM-I-V*" of the software, and then we can get the results we want.

Now, we will show the results we obtain.

Table 4.13 SBM – Input Excesses of Selected Banks

DMU	Score	Excess (s^-)					
		Operating Expenses		Assets		Number of Employees	
		Volume	α_{1n}	Volume	α_{2n}	Volume	α_{3n}
ICBC	1	0	0.00%	0	0.00%	0	0.00%
CCB	1	0	0.00%	0	0.00%	0	0.00%
ABC	1	0.326	0.0002%	0	0.00%	2.72	0.001%
BOC	1	0.162	0.0001%	22.878	0.0001%	0.744	0.0002%
BOCM	0.7428	32350.9	33.67%	1492147	22.90%	19974.6	20.58%
CMBC	1	0	0.00%	0	0.00%	0	0.00%
CMSB	1	0	0.00%	0	0.00%	0	0.00%
BIC	1	1.552	0.002%	3.969	0.0001%	0.673	0.001%
CITIC	1	0	0.00%	0	0.00%	0	0.00%
SPDB	1	0	0.00%	0	0.00%	0	0.00%
BJB	1	0	0.00%	0	0.00%	0	0.00%
HZB	1	0	0.00%	0	0.00%	0	0.00%
Unit of Volume: million CNY							

Here, the list of "Volume" refers to the true value of slacks of each bank. "Score" is the efficient ratio of each bank. "α_{mn}" means the percentage changes of each input item if banks pay attention to solve current condition and achieve efficiency. And we use the Formula (2.19) to measure and obtain results.

As we can see from the Table 4.13, we find the input excesses situation of each bank, the banks who obtain the score $\theta^* = 1$ means that the bank has no input excess, here we select 12 banks to analyze, and just one of them has the input excesses, which is BOCM.

From the Table 4.13 we can also obtain the average sore of all banks is 0.979.

There are four banks in input excesses of operating expenses, while except BOCM, the remaining three banks absolute value of input excesses is very short that can even ignore it. The same as input excesses in assets, there are three banks have input excesses of assets but also can ignore except BOCM bank whose percentage changes of this item is about 23 per cent. Similar in number of employees' item, total four banks are in input excesses, all of them are very small that can be ignored except BOCM. Hence, there is one and only one bank has input excesses which named BOCM.

Table 4.14 SBM – Output Shortfalls of Selected Banks

DMU	Shortfall (s^+)							
	Operating Incomes		New Loans		New Deposits		ROE	
	Volume	β_{1n}	Volume	β_{2n}	Volume	β_{3n}	Volume	β_{4n}
ICBC	0	0.00%	0	0.00%	0	0.00%	0	0.00%
CCB	0	0.00%	0	0.00%	0	0.00%	0	0.00%
ABC	0	0.00%	0.46	0.00%	0	0.00%	0	0.00%
BOC	0	0.00%	0.519	0.00%	0	0.00%	0	0.00%
BOCM	0	0.00%	30787.9	10.92%	40678.5	13.41%	0.007	5.15%
CMBC	0	0.00%	0	0.00%	0	0.00%	0	0.00%
CMSB	0	0.00%	0	0.00%	0	0.00%	0	0.00%
BIC	0	0.00%	12.817	0.01%	3.041	0.001%	0	0.00%
CITIC	0	0.00%	0	0.00%	0	0.00%	0	0.00%
SPDB	0	0.00%	0	0.00%	0	0.00%	0	0.00%
BJB	0	0.00%	0	0.00%	0	0.00%	0	0.00%
HZB	0	0.00%	0	0.00%	0	0.00%	0	0.00%
Unit of Volume: million CNY (except ROE)								

Here, except the ROE item all items use the unit of million CNY. "β_{sn}" is the percentage change of each output item if banks want to solve the output shortfall to achieve the efficiency.

From the Table 4.14 we can find the output shortfalls situation of each banks. For about operating incomes, all banks have 0 per cent which means there is no bank in shortfall in this item. For about the item of new loan, there are four banks in shortfalls, however, three of the four is close to 0 per cent which can be ignore, therefore, BOCM is the only one who has output shortfalls. Then in new deposits and ROE are also the same, BOCM is the only one bank in output shortfalls.

Table 4.15 SBM –Weights of Input Items & Output Items

DMU	V_1 Operating Expense	V_2 Assets	V_3 Number of Employees	U_1 Operating Incomes	U_2 New Loans	U_3 New Deposits	U_4 *ROE*
ICBC	3.88	0.33	0.33	0.00	4.55	0.00	0.00
CCB	2.46	0.33	0.33	0.00	0.25	2.88	0.00
ABC	0.33	1.14	0.33	0.23	0.88	0.00	1.15
BOC	0.33	0.33	0.33	0.16	0.59	0.00	0.58
BOCM	0.33	0.33	0.33	0.24	0.98	0.00	0.00
CMBC	0.33	216.93	0.33	0.00	62.48	68.79	81.99
CMSB	0.33	32.54	0.33	0.00	0.00	0.00	33.20
BIC	0.33	0.33	0.33	1.20	1.09	0.00	0.00
CITIC	133.00	0.33	32.87	0.00	0.00	70.60	95.61
SPDB	0.33	1.22	1.84	0.00	3.40	0.00	0.00
BJB	0.33	149.78	0.33	0.00	2.88	132.79	0.00
HZB	2499.11	0.33	0.33	0.00	0.00	63.97	105.11

Here V_n and U_n means the weight of each item of input and output for each bank.

From the table above we can clearly see the weight of each item for every bank. We find the BOCM bank's performance is worst, no weights of whole items of it are higher than 40 per cent except weight of new loans.

The lower is input and higher is output, the better will the bank be. Hence, if one item's weight value is low means the bank does not manage it well and there is an inefficient, on the contrary, if one item's weight value is high means the bank manages it well and there is an efficient.

Table 4.16 SBM – Reference Set of Inefficient Banks

Inefficient Banks	Scores	Reference (λ^*)				
BOCM	0.7428	CCB	0.017	CMBC	0.983	

Hence, from analyzing the input excesses and output shortfalls, we find there only one bank is inefficient which named BOCM. From this situation, we say that the performance of banks who earn more than 400000 million CNY are better than the performance of banks who earn lower than 400000 million CNY, because the only bank

who is inefficient belongs to list B (banks earns lower than 400000 million).

Hence, BOCM should pau more attention to solve its problems to improve current situation and makes its efficiency better. From the tables above, we find the biggest problem of it is the operating expenses, which is even higher than 30 per cent. Hence, the bank need to focus on decreasing the cost in operating. For example, BOCM may need to reduce the staff in order to reduce the costs and can also help adjust the excesses number of employees as well.

Table 4.17 SBM –Projection of Inefficient Bank

		Operating Expense	Assets	Number of Employees	Operating Incomes	New Loans	New Deposits	*ROE*
BOCM	Data	96076.95	6515935.15	97072.65	179216.70	282044.40	303242.13	0.136
	Projection	63726.028	5023788.01	77098.03	179216.70	312832.31	343920.67	0.142
0.743	Diff.	-32350.92	-1492147.14	-19974.62	0.00	30787.91	40678.54	0.007
	(%)	-33.67	-22.90	-20.58	0.00	10.92	13.42	4.840
Unit: million CNY								

Here in the table, the "*Data*" lines are the weighted mean value from 2011 to 2015 of original data for each item of banks. The "*Projection*" lines refer to the developed number of each item in the SBM-efficient. The "*Diff.*" is the difference between original data and projection data. "*(%)*" means the elimination and the adjunction to the inputs and outputs of each selected bank.

Score of $\theta^* = 0.743$;

$\lambda^*_2 = 0.017$, $\lambda^*_6 = 0.983$ and other $\lambda^*_j = 0$; and the reference set for BOCM is: $E_5 = \{CCB_2, CMBC_6\}$

The input excesses and output shortfalls are: $s_1^- = 323509.9$ (operating expenses), $s_2^- = 1492147.1$ (Assets), $s_3^- = 19974.6$ (number of employees), $s_2^+ = 0$ (Operating incomes), $s_2^+ = 30787.9$ (new loans), $s_3^+ = 40678.5$ (new deposits), $s_4^+ = 0.007$ (ratio of ROE);

By using the data we obtain we can calculate the projection of it by using the Formula (2.18).

$$\widehat{x_o} \leftarrow x_o - s^{-*}$$

$$\widehat{y_o} \leftarrow y_o + s^{+*}$$

Therefore,

$$\widehat{x_1} \leftarrow x_1 - {s_1}^- = 96076.9 - 32350.9 = 63726.0;$$

$$\widehat{x_2} \leftarrow x_2 - {s_2}^- = 6515935.1 - 1492147.1 = 5023788.0;$$

$$\widehat{x_3} \leftarrow x_3 - {s_3}^- = 97072.6 - 19974.6 = 77098.0;$$

$$\widehat{y_1} \leftarrow y_1 + {s_1}^+ = 179216.7 + 0 = 179216.7;$$

$$\widehat{y_2} \leftarrow y_2 + {s_2}^+ = 282044.4 + 30787.9 = 312832.3;$$

$$\widehat{y_3} \leftarrow y_3 + {s_3}^+ = 303242.1 + 40678.5 = 343920.6;$$

$$\widehat{y_4} \leftarrow y_4 + {s_4}^+ = 0.136 + 0.007 = 0.142.$$

And from the Table 4.19 we can obtain the difference between original data and projection data with percentage.

After applying the SBM model, we find that the efficiency result from SBM mode is better than the result from CCR model. The former one has four banks in inefficient situation while in SBM model there is only one bank in inefficient situation which is BOCM bank.

And the score in SBM is lower than it in CCR.

$\rho^* = 0.743 < \theta^* = 0.769$

Table 4.18 SBM – Return to Scales of Selected Banks

No.	DMU	Score	RTS of Projected DMU
1	ICBC	1	Constant
2	CCB	1	Constant
3	ABC	1	Decreasing
4	BOC	1	Decreasing
5	BOCM	0.7428	Constant
6	CMBC	1	Constant
7	CMSB	1	Constant
8	BIC	1	Decreasing
9	CITIC	1	Constant
10	SPDB	1	Constant
11	BJB	1	Constant
12	HZB	1	Constant

From Table 4.18 we can find the return-to-scale of each bank. There are three banks in decreasing return-to-scales which are ABC, BOC and BIC, while those three banks all are efficient banks. Other banks are constant return-to-scale which includes the inefficient bank, BOCM.

SBM – Summary

By applying the SBM model which is the one of a typical non-radial model in DEA model based on CCR model.

We find that there is only one bank in inefficient. And other are efficient which means they do not have any input excesses or output shortfalls.

Similar to the result we applying in CCR, the bank whose performance is worst is BOCM. But in fact, in SBM model it becomes the only one who is inefficient.

In order to solve the inefficient situation, the bank needs to improve its input excess and output shortfalls. Hence we use the "*SBM-I-V*" in *DEA-Solver-LV* (version8) to obtain the result of projection data for them.

The biggest problem we applied by SBM model of banks is operating expense, which means that bank earn such amount of profit by using too much expense, one of the large wasting expense is the expense of wages and salaries which we have talk about

during the CCR model. Hence, the bank should cut some of employees or reduce the wages and salaries.

However, we think it is not perfect enough, hence we will then make some stretches of this model and make our result much better.

4.2.4 SBM Model Stretching

In this part we will make out analysis more accurate, we will split our input and output items into smaller parts.

Putting them into several groups, for example, one input item with four output items or one output item with three input items.

According to these now we can obtain 7 groups which shows as following.

Table 4.19 SBM –New Groups of Input and Output Items

Group1 (G1)	(I)Operating Expenses	(O)Operating Income	(O)New Loans	(O)New Deposits	(O)ROE
Group2 (G2)	(I)Assets	(O)Operating Income	(O)New Loans	(O)New Deposits	(O)ROE
Group3 (G3)	(I)Number of Employees	(O)Operating Income	(O)New Loans	(O)New Deposits	(O)ROE
Group4 (G4)	(I)Operating Expenses	(I)Assets	(I)Number of Employees	(O)Operating Incomes	
Group5 (G5)	(I)Operating Expenses	(I)Assets	(I)Number of Employees	(O)New Loans	
Group6 (G6)	(I)Operating Expenses	(I)Assets	(I)Number of Employees	(O)New Deposits	
Group7 (G7)	(I)Operating Expenses	(I)Assets	(I)Number of Employees	(O)ROE	

According to the new groups we obtain, we will apply the "*SBM-I-V*" in "*DEA-*

Solver-LV (version 8)" as well as use the previous part.

We will get new scores of each group.

Table 4.20 SBM – Scores of Each Group & Each Bank

No.	DMU	Score							Average	Std.	Variation Coefficient
		G1	G2	G3	G4	G5	G6	G7			
1	ICBC	1	1	1	1	**1.00**	0.85	0.21	0.87	0.29	33.9%
2	CCB	1	1	1	1	1	0.87	0.26	0.88	0.28	31.6%
3	ABC	1	1	1	0.82	0.74	1	0.17	0.82	0.31	37.4%
4	BOC	1	0.92	1	0.90	0.80	1	0.06	0.81	0.34	41.6%
Average		1	0.98	1	0.93	0.89	0.93	0.18	0.84		
Std.		0.00	0.04	0.00	0.09	0.14	0.08	0.08			
Variation Coefficient		0.0%	4.1%	0.0%	9.4%	15.3%	8.6%	47.3%			
5	BOCM	0.66	0.77	0.79	0.74	0.66	0.62	0.08	0.62	0.25	39.6%
6	CMBC	1	1	1	1	1	1	0.17	0.88	0.31	35.6%
7	CMSB	0.93	1	1	0.87	0.77	1	0.74	0.90	0.11	12.5%
8	BIC	1	1	1	0.93	0.69	0.69	1	0.90	0.15	16.3%
9	CITIC	1	0.91	1	1	0.92	1	0.12	0.85	0.32	38.2%
10	SPDB	1	1	1	1	1	0.75	0.91	0.95	0.09	10.0%
11	BJB	1	1	1	1	1	1	1	1	0.00	0.0%
12	HZB	1	1	1	1	1	1	1	1	0.00	0.0%
Average		0.95	0.96	0.97	0.94	0.88	0.88	0.63	0.89		
Std.		0.12	0.08	0.07	0.09	0.15	0.16	0.43			
Variation Coefficient		12.7%	8.6%	7.5%	10%	17.0%	18.7%	68.1%			
Total Average		0.97	0.97	0.98	0.94	0.88	0.90	0.48	0.87		
Total Std.		0.10	0.07	0.06	0.09	0.14	0.14	0.41			
Total Variation Coefficient		10.3%	7.2%	6.0%	9.4%	15.7%	15.6%	85.8%			

From the Table 4.20 we can directly see efficient scores of each group for all banks we selected. The line "*Variation Coefficient*" refers to the value measured from the standard deviation value divided by the average value. It means if one bank get low variation coefficient value, this bank has a relatively low standard deviation and relatively high efficient score which represents that the bank performance relatively better.

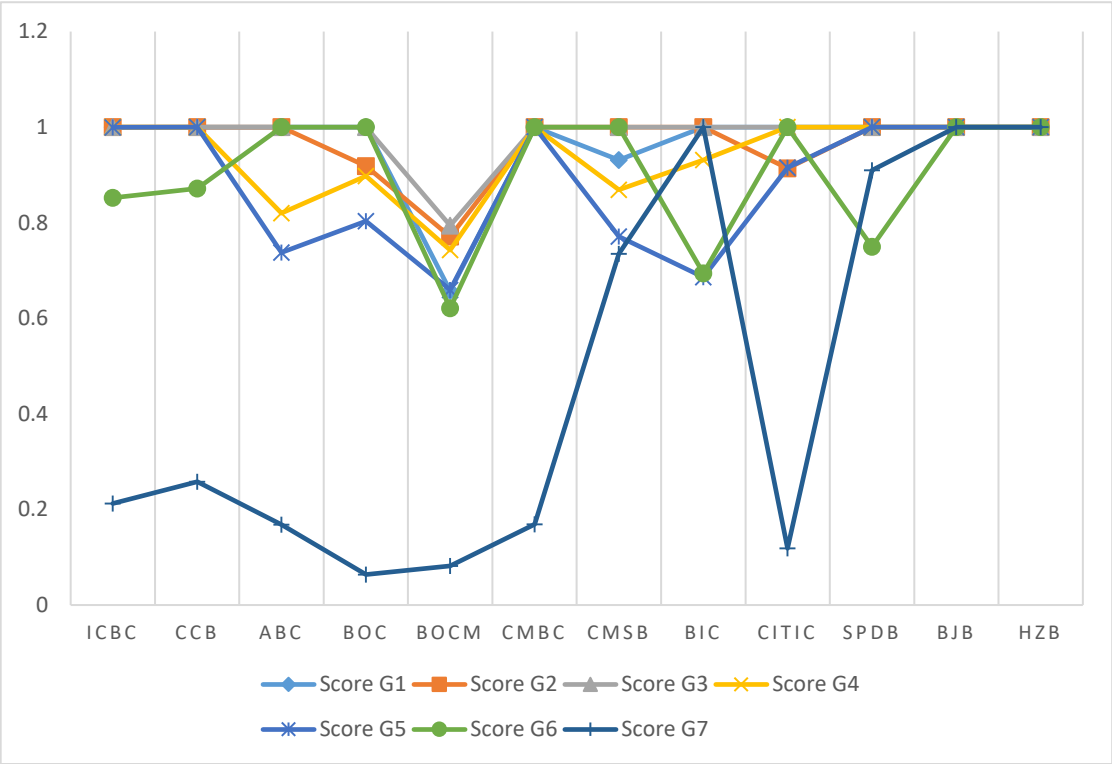
By comparing the vertical variation coefficient value of each bank we find there

are two banks, BJB and HZB (both are regional commercial banks) whose value is 0 per cent, which means their standard deviation is very low and their efficient score is high, in a word, their performances are good than other remaining banks. Then except these two banks, we find the bank who has the best performance is SPDB, its variation coefficient is 10.0 per cent. However, the four big banks' variation coefficient values are all higher than 30 per cent.

Here the score of G5 in ICBC is overstriking which is "1.00", it looks like the bank in G5 is efficient. In fact, ICBC's score in G5 is 0.998 which is very close to 1 but still inefficient. Hence we emphasize it by overstriking.

The total average of all 12 banks in 7 groups' scores is around 0.87, while the average score of four big banks is 0.84 which is lower than total average score. On the contrary, the average in remaining relative eight small banks is 0.89 which is higher than total average score. This means the performance of small banks is better than big banks.

Chart 4.2 SBM – Efficient Score of Each Group in All Banks



Here from the Chart 4.2 we use the 12 banks as our *X* axis. We can find the performance of banks in different groups, for example, the total average performance of Group 7 is worst, some banks' efficient score of it are even lower than 0.2 point.

Chart 4.3 SBM –Score of Each Bank in All Groups

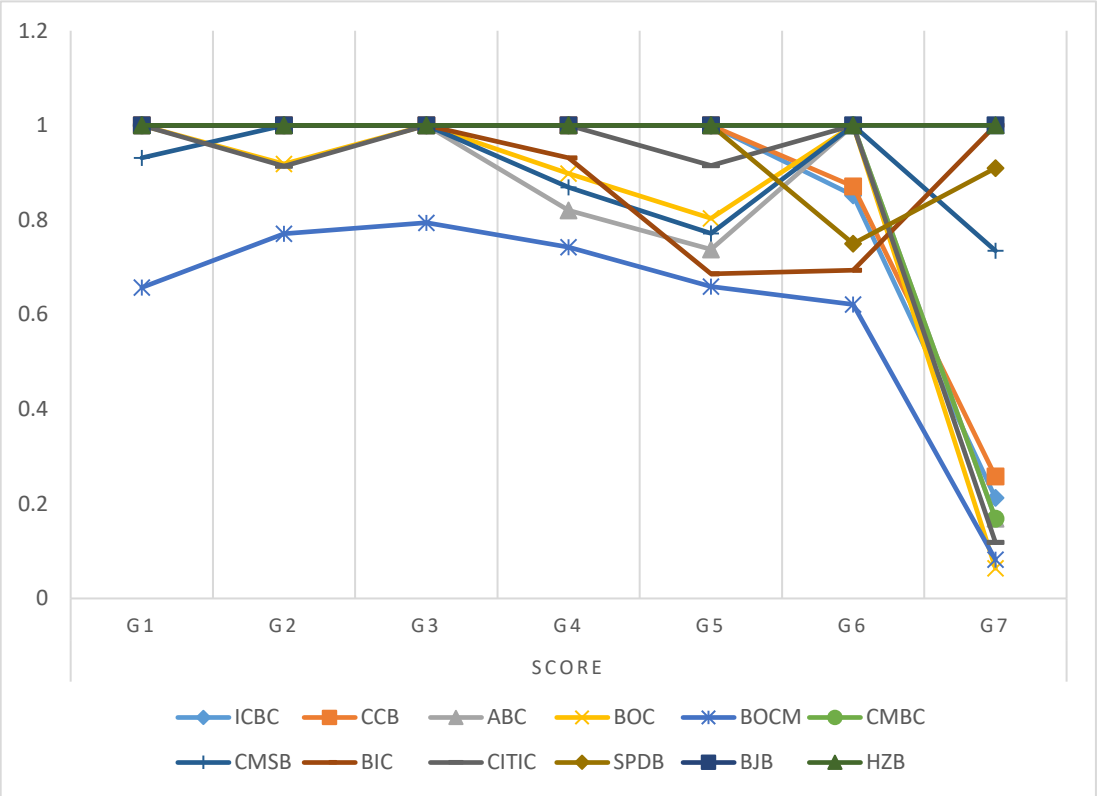


Chart 4.3 is similar to the previous one, we just change the *X* axis to 7 Groups. And we can find which group one bank's performance is worst. For example, the most inefficient score of BOC bank is G7 which is even lower 0.2 point.

HZB and BJB two banks' performances are the best, we can easily see their efficient scores are all equal to 1 point, which means they have neither input excesses nor output shortfalls.

Chart 4.4 SBM – Score of Each Banks in Each Groups

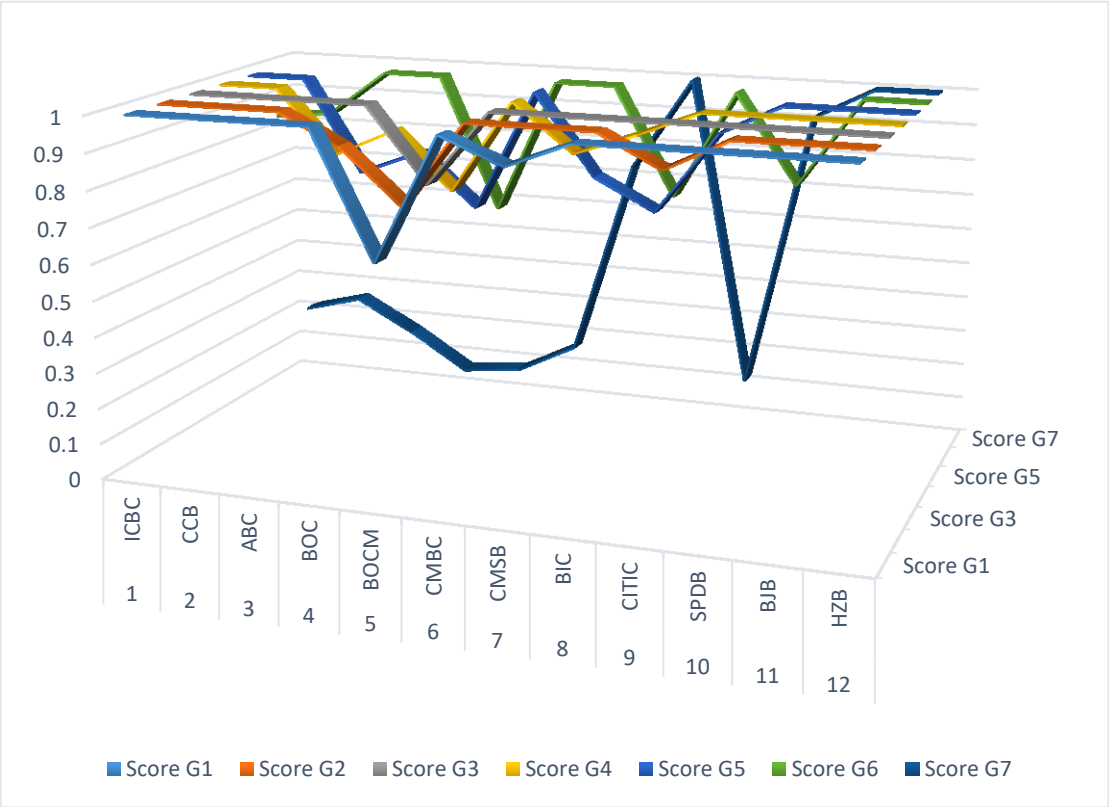


Chart 4.4 is like the combination of previous two charts. We use both 7 groups and 12 banks as our *X* axis. And we can see the whole performance tendency of all banks in all groups.

Table 4.21 SBM – Return-to-Scale of Each Bank in Each Group

No.	DMU	G1	G2	G3	G4	G5	G6	G7
1	ICBC	C	D	D	C	D	D	D
2	CCB	C	D	D	C	C	D	D
3	ABC	D	D	D	C	C	D	D
4	BOC	D	D	D	C	C	D	D
5	BOCM	C	D	D	C	C	C	D
6	CMBC	C	C	D	C	C	C	D
7	CMSB	D	C	D	I	C	C	D
8	BIC	D	D	D	C	C	C	D
9	CITIC	C	C	D	C	C	C	C
10	SPDB	D	D	D	C	D	C	D
11	BJB	C	C	C	C	C	C	D
12	HZB	C	C	C	I	I	C	C
C = Constant, D = Decreasing, I = Increasing								

From the Table 4.21 we can clearly see the return-to-scale of all 12 banks in different groups. There are only two groups have the increasing return-to-scale which are G4 and G5, in former one which pay attention only to the output item operating incomes, CMSB and HZB are in increasing return-to-scale, it means they can improve their operating income, while in G5 who focus on the output item new loans there is only HZB has the increasing return-to-scale which means HZB can increasing its providing of loans and make more assets. Both of them are in the group of small banks (the bank that earn operating incomes lower than 400000 million CNY).

The largest amount of return-to-scale is decreasing one, for example, in G3, the one who pays attention only to number of employees, almost all banks are decreasing return-to-scale except BJB and HZB which are in constant return-to-scale.

ICBC, ABC, BOC and SPDB, these four banks have five decreasing return-to-scales of seven groups. And three of them are big banks (who earn operating incomes higher than 400000 million CNY). And most of small banks have fewer decreasing return-to-scales than constant return-to-scales they have.

Which means the performance of small banks is better than the performance of large banks.

From previous we find the banks who have better performance are BJB and HZB which both are small banks, and moreover, both of them are regional commercial banks (even small).

The worst performance are BOC bank and BOCM bank. BOC's variation coefficient value is highest, about 41.6 %, it means that the bank has relatively high standard deviation and relatively low efficient score. While BOCM has the lowest average sufficient score, around 0.62 point.

And all of the large banks have average efficient score lower than 1 point which means all of them are inefficient. On the contrary, there are two small banks are efficient, they do not have any input excesses or output shortfalls.

4.3 Summary

In this chapter, we emphasize the weight of each year we used at the beginning.

Then we make the financial ratios analysis for all banks we chosen, in order to know their current financial situation during 2011 to 2015. We use profitability ratios, credit risk ratios, efficiency ratios and other important ratio.

By this analysis, we find that all banks' performances are relative stable during these years, and the profitability of the four banks whose operating income is more than 400000 million CNY is better than other seven banks. And we also find that the operating expense of eight banks whose operating income is lower than 400000 million CNY has larger proportion of operating revenues than it in the other four banks.

After that we apply CCR model and SBM model to analyze the 12 banks we selected. For about the software, we use "*DEA-Solver-LV* (Version8)".

First is CCR model, which is a typical radial method in DEA models, and it is also the most basic method of DEA models. After applying this model, we find there are three banks in inefficient situation, BOCM, ABC, BOC. BOCM has the lowest efficiency score which means it is the most inefficient bank. But as for proportion, the proportion of two groups who has bigger inefficient banks is the large banks groups. Because there are two of four in inefficient situation. The small banks group only have one in inefficient situation.

Then we use SBM model, which is based on CCR model and is a kind of non-radial model in DEA. After applying, we find there is only one bank in inefficient situation, BOCM, whose efficiency score is 0.743. It belongs to the small banks group. And then we try to calculate the projection value if the bank wants to change its current condition and make itself be efficient enough.

We find the excesses of operating expenses and excesses of number of employees are the most serious problems that make banks be inefficient. In order to improve the level of efficiency, banks need to decrease their operating expenses such as decrease number of staffs and then their costs to pay for wages and salaries will be lower and the excesses of number of employees will also be better than before.

Some banks have already begun to reduce their number of staff. As in 2016, the four large state owned banks, ICBC, BOC, ABC and CCB reduce totally about 25 thousand number of employees, at the same time, the wages and salaries of some banks are decreased as well.

According to Wall Street News on Aug. 31st 2016, as of June 30th, in just six months this year, BOC reduces around 6881 of its employees, ABC cuts 4023, ICBC cuts 7635 and CCB reduces 6721 employees. In 2016 there are totally nine banks reduce their number of staff, except the four large banks, the national commercial bank BOCM cuts 577 employees, CMBC cuts 7768 employees, which is around 10 per cent of its whole number of staff, is the largest in these nine banks.

At the same time as layoffs, China's 16 listed banks, 10 banks per capita salary decline in varying degrees. For example, the expenses of wage and salaries in 2016 of ICBC is about 780 million CNY lower than it in last year, which is about 1.6 per cent reducing degree. In ABC, the expenses of wages and salaries in 2016 is about 1553 million CNY lower which the reducing degree is 2.9 per cent.

And finally we try to stretch the SBM model. We divide our output and input items into 7 groups, and we analyze each groups' situation of all banks. We find worst groups are G3 and G7. The former one focus on number of employees and the other one pay attention to ROE. Which means the waste number of employees and the low net profits can be big problems for banks. In this section, just two banks are totally efficient, which are BJB HZB, both of them are in small banks group, and both of them are regional commercial banks as well.

5. Conclusion

The main topic of our thesis is analyzing the efficiency situation of selected Chinese commercial banks by using the Data Envelopment Analysis model.

We choose 12 banks as our objects, and the basic data we use financial statements from their annual reports during 2011 to 2015.

In chapter 2, we described some principal of DEA model we applied. First we explain something about “efficiency”, and then we describe DEA model in detail. After that we introduce the model we used for which are CCR model and SBM model. CCR model is typical radial model and basic model in DEA model. While SBM is based on CCR model, and it is a non-radial model in DEA model. Finally, we described what software we used in our thesis, it is *DEA-Solver-LV*, here we use version 8.

Then in chapter 3, we introduced some basic information of our selected banks. Firstly, we explain the whole banking system in China and we made short SWOT analysis for it. And then we divided our 12 banks into 2 groups according to the amount of operating incomes they earn during these 5 years. We also introduced something about financial statements, income statements and balance sheets, and we showed the 12 banks’ financial statements here. After that we describe financial ratios, profitability ratios, risk ratios, efficiency ratios and so on. And we also put the result of banks’ ratios in this chapter.

Then is the main chapter 4, here we analyzed 12 banks’ efficiency situation by applying the models we described in chapter 2. We used “weights” for each year. First, we applied the financial analysis of banks, from this part we know the financial situation of them.

We applied the CCR model, and we find that there are four banks that are inefficient which are BOCM, ABC, BOC and BIC. And other are efficient which means they do not have any input excesses or output shortfalls. And BOCM’s performance is worst. The small banks’ performance is better than big banks. Because there are half of inefficient banks are big banks who earn operating income more than 400000 million

CNY per year.

Then is the application of SBM model, which is based on CCR model. We find that there is only one bank in inefficient. And other are efficient which means they do not have any input excesses or output shortfalls .Similar to the result we applying in CCR, the bank whose performance is worst is BOCM. But in fact, in SBM model it becomes the only one who is inefficient.

After that we stretched SBM model, we divided our items of input and output into 7 groups. And finally we find the most serious problems for the inefficient banks are their excesses of number of employees and shortfalls of *ROE*. Hence banks need to cut some number of their staff in order to solve the excesses decrease the operating expenses and make higher profit to make themselves efficient. Besides, banks can also improve the technology such as internet banking to reduce the cost of labor, for example, some service can be used by computer rather than employees such as the self-picking.

In fact, the BOCM bank decides to cut 15 per cent of its employees in the year of 2016 and some other banks have already begun to reduce their number of staff and decrease the wages and salaries. This will make the lower operating expenses, higher operating profits, but the unemployment will increasing as well. This makes more difficult to find a job in China in the banking industry.

By the development of technology, there are more technology can replace the manual, this is one reason that why there is wasting of employees expense. Hence, from the trend that the banking industry downsizing, this has just begun. Because of the lower profit, banks have more incentive to use internet banks, self-servicing banking, etc. to replace the expensive labor to reduce long-term human spending.

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List of Abbreviations

DEA	Data Envelopment Analysis
DMU	Decision-Making Unit
CCR	Charnes, Cooper and Rhodes
SBM	Slacks-Based Measure of Efficiency
DEA-Solver-LV	DEA-Solver-Learning Version
RTS	Return-to-Scales
ICBC	Industrial & Commercial Bank of China Limited
CCB	China Construction Bank Corp.
ABC	Agricultural Bank of China Ltd.
BOC	Bank of China Ltd.
CMBC	China Merchants Bank Co. Ltd.
BOCM	Bank of Communications Co. Ltd.
CITIC	China CITIC Bank Co. Ltd.
CMSB	China Minsheng Banking Corp. Ltd.
SPDB	Shanghai Pudong Development Bank Co. Ltd.
BIC	Industrial Bank Co. Ltd.
BJB	Bank of Beijing Co. Ltd.
HZB	Bank of Hangzhou Co. Ltd.
CNY	Chinese Yuan
CRS	Constant Return-to-Scale
VRS	Variable Return-to-Scale
ROE	Return on Equity
EAT	Earning After Tax
EBT	Earning Before Tax
TE	Total Equity
ROA	Return on Assets
TA	Total Assets

NIM	Net Interest Margin
NII	Net Interest Income
NPM	Net Profit Margin
NI	Net Income
TOR	Total Operating Revenues
LLA	Loan Loss Allowance
LTD	Loan to Deposit
CAR	Capital Adequacy Ratio
RWA	Risk Weight Assets
WAV	Weighted Average Value
OER	Operating Efficiency Ratio
EPR	Employee Productivity Ratio
EM	Equity Multiplier
Std.	Standard Deviation
Diff.	Difference

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Ostrava dated 21.04.2017

XIAO HAN

List of Annexes

Annexes 1: Statistics and Correlation on Input / Output Data by CCR

Statistics on Input / Output Data

	Operating Expenses	Assets	Number of Employees	Operating Incomes	New Loans	New Deposits	ROE
Max	215286	20711607	491762	628703	995421	931312	0.176
Min	6867	456386	5315	11290	20649	31742	0.127
Average	103769	8352314	166838	255115	423768	435115	0.156
SD	71863	6637044	174430	206080	337921	313275	0.017

Correlation

	Operating Expenses	Assets	Number of Employees	Operating Incomes	New Loans	New Deposits	ROE
Operating Expenses	1	0.979	0.969	0.978	0.967	0.981	0.499
Assets	0.979	1	0.969	0.996	0.989	0.978	0.444
Number of Employees	0.969	0.969	1	0.973	0.964	0.973	0.435
Operating Incomes	0.978	0.996	0.973	1	0.996	0.980	0.465
New Loans	0.967	0.989	0.964	0.996	1	0.973	0.468
New Deposits	0.981	0.978	0.973	0.980	0.973	1	0.397
ROE	0.499	0.444	0.435	0.465	0.468	0.397	1

Annexes 2: Statistics and Correlation on Input / Output Data by SBM

Statistics on Input / Output Data

	Operating Expenses	Assets	Number of Employees	Operating Incomes	New Loans	New Deposits	ROE
Max	215286	20711607	491762	628703	995421	931312	0.176
Min	6867	456386	5315	11290	20649	31742	0.127
Average	103769	8352314	166838	255115	423768	435115	0.156
SD	71863	6637044	174430	206080	337921	313275	0.017

Correlation

	Operating Expenses	Assets	Number of Employees	Operating Incomes	New Loans	New Deposits	ROE
Operating Expenses	1	0.979	0.969	0.978	0.967	0.981	0.499
Assets	0.979	1	0.969	0.996	0.989	0.978	0.444
Number of Employees	0.969	0.969	1	0.973	0.964	0.973	0.435
Operating Incomes	0.978	0.996	0.973	1	0.996	0.980	0.465
New Loans	0.967	0.989	0.964	0.996	1	0.973	0.468
New Deposits	0.981	0.978	0.973	0.980	0.973	1	0.397
ROE	0.499	0.444	0.435	0.465	0.468	0.397	1

Annexes 3: Income Statements of Banks from 2011 to 2015

	2011	2012	2013	2014	2015
ICBC					
Net Interest Income	362764	417828	443335	493522	507867
Noninterest Income	107837	111892	135566	141336	160866
Operating Income	470601	529720	578901	634858	668733
Operating Expense	169613	189940	204140	218674	220835
Operating Profit	269867	306035	336440	359455	360905
Net Profit	208445	238691	262965	276286	277720
CCB					
Net Interest Income	304572	353202	389544	437398	457752
Noninterest Income	94831	109331	121596	119342	128935
Operating Income	399403	462533	511140	556740	586687
Operating Expense	144537	171081	188185	195988	194826
Operating Profit	254866	291452	322955	360752	391861
Net Profit	169439	193602	215122	228247	228886
BOC					
Net Interest Income	228064	256964	283585	321102	328650
Noninterest Income	100234	109212	123924	135226	145262
Operating Income	328298	366176	407509	456328	473912
Operating Expense	140412	159314	172314	177788	185402
Operating Profit	168531	187060	211685	230159	229236
Net Profit	130848	145746	163741	177198	179417
CMBC					
Net Interest Income	76307	88374	98913	112000	136729
Noninterest Income	20359	25444	34205	54525	65573
Operating Income	96666	113818	133118	166525	202302
Operating Expense	40889	48356	54144	61081	67670
Operating Profit	55777	65462	78974	105444	134632
Net Profit	36129	45268	51743	55911	57696
BOCM					
Net Interest Income	103493	120126	130658	134775	144172
Noninterest Income	23463	27211	33777	42626	49656
Operating Income	126956	147337	164435	177401	193828
Operating Expense	61505	72126	84526	92474	107816
Operating Profit	65451	75211	79909	84927	86012
Net Profit	50735	58369	62295	65850	66528
ABC					
Net Interest Income	307199	341879	376202	429891	436140
Noninterest Income	72557	83085	89569	94235	104722

Operating Income	379756	424964	465771	524126	540862
Operating Expense	157330	182802	198607	223898	225818
Operating Profit	158201	187927	214174	232257	230857
Net Profit	121956	145131	166211	179510	180774
CITIC					
Net Interest Income	65106	75486	85689	94741	104433
Noninterest Income	11986	14225	19124	30098	41112
Operating Income	77092	89711	104813	124839	145545
Operating Expense	28381	34979	40435	46796	50602
Operating Profit	48711	54732	64378	78043	94943
Net Profit	21462	24014	27385	40692	30784
CMSB					
Net Interest Income	64821	77153	83033	92136	94268
Noninterest Income	35065	25958	32853	43333	60157
Operating Income	99886	103111	115886	135469	154425
Operating Expense	51932	52379	59083	75990	94175
Operating Profit	47954	50732	56803	59479	60250
Net Profit	27920	37563	42278	44546	46111
SPDB					
Net Interest Income	61442	73362	85177	98183	113009
Noninterest Income	6558	9925	14838	24998	33541
Operating Income	68000	83287	100015	123181	146550
Operating Expense	32161	38533	46492	61430	80483
Operating Profit	35839	44754	53523	62030	66877
Net Profit	27286	34186	40922	47026	50604
BIC					
Net Interest Income	50734	72193	85845	95560	119834
Noninterest Income	9046	15426	23442	29338	34514
Operating Income	59780	87619	109287	124898	154348
Operating Expense	26338	41551	55209	64708	91538
Operating Profit	33664	46193	54261	60598	63244
Net Profit	25505	34718	41211	47138	50207
BJB					
Net Interest Income	18772	24623	26285	31285	35785
Noninterest Income	1613	2672	3951	5593	8296
Operating Income	20385	27295	30236	36878	44081
Operating Expense	9377	13063	13895	17957	23045
Operating Profit	11008	14232	16341	18921	21036
Net Profit	8946	11684	13465	15646	16883
HZB					
Net Interest Income	6726	8842	9158	9295	11037
Noninterest Income	786	946	617	1732	1367

Operating Income	7512	9788	9775	11027	12404
Operating Expense	4155	5331	5028	6709	7907
Operating Profit	3357	4457	4747	4318	4497
Net Profit	2691	3558	3799	3511	3705
					Unit: million CNY

Annexes 4: Balance Sheets of Banks from 2011 to 2015

	2011	2012	2013	2014	2015
ICBC					
Total Assets	15476868	17542217	18917752	20609953	22209780
Total Loans	7788897	8803692	9922374	11026331	11933466
Loan Loss Allowance	194878	220403	240959	257581	280654
Net Loans	7594019	8583289	9681415	10768750	11652812
Deposit	12261219	13642910	14620825	15556601	16281939
Total Liabilities	14519045	16413758	17639289	19072649	20409261
Total Equity	957823	1128459	1278463	1537304	1800519
CCB					
Total Assets	12281834	13972828	15363210	16744093	18349489
Total Loans	6496411	7512312	8590057	9474510	10485140
Loan Loss Allowance	171217	202433	228696	251613	250617
Net Loans	6325194	7309879	8361361	9222897	10234523
Deposit	9987450	11343079	12223037	12898675	13668533
Total Liabilities	11465174	13023283	14288881	15492245	16904406
Total Equity	816660	949545	1074329	1251848	1445083
BOC					
Total Assets	11829789	12680615	13874299	15251382	16815597
Total Loans	6342814	6864696	7607791	8483275	9135860
Loan Loss Allowance	139676	154656	168049	188531	200665
Net Loans	6203138	6710040	7439742	8294744	8935195
Deposit	8817961	9173995	10097786	10885223	11729171
Total Liabilities	11072652	11819073	12912822	14067954	15457992
Total Equity	757137	861542	961477	1183428	1357605
CMBC					
Total Assets	2794971	3408099	4016399	4731829	5474978
Total Loans	1641075	1904463	2197094	2513919	2824286
Loan Loss Allowance	36704	41138	48764	65165	84842
Net Loans	1604371	1863325	2148330	2448754	2739444
Deposit	2220060	2532444	2775276	3304438	3571698
Total Liabilities	2629961	3207698	3750443	3316769	5113220
Total Equity	165010	200401	265956	1415060	361758
BOCM					
Total Assets	4611177	5273379	5960937	6268299	7155362
Total Loans	2618115	3014970	3339673	3508683	3809444
Loan Loss Allowance	56365	67671	73305	76948	87438
Net Loans	2561750	2947299	3266368	3431735	3722006
Deposit	3288232	3728412	4157833	4029668	4484814

Total Liabilities	4338389	4891932	5539453	5794694	6617270
Total Equity	272788	381447	421484	473605	538092
ABC					
Total Assets	11677577	13244342	14562102	15974152	17791393
Total Loans	5639928	6433399	7224713	8098067	8909918
Loan Loss Allowance	229842	279988	322191	358071	403243
Net Loans	5410086	6153411	6902522	7739996	8506675
Deposit	9622026	10862935	11811411	12533397	13538360
Total Liabilities	11027789	12492988	13717565	14941533	16579508
Total Equity	649788	751354	844537	1032619	1211885
CITIC					
Total Assets	2765881	2959939	3541193	4138815	5122292
Total Loans	1410779	1627576	1899921	2136332	2468283
Loan Loss Allowance	23258	35325	41254	51576	60497
Net Loans	1387521	1592251	1858667	2084756	2407786
Deposit	1968051	2255141	2651678	2849574	3182775
Total Liabilities	2589100	2756853	3410468	3871469	4802606
Total Equity	176781	203086	130725	267346	319686
CMSB					
Total Assets	2229064	3212001	3226210	4015136	4520688
Total Loans	1205221	1384610	1574263	1812666	2048048
Loan Loss Allowance	26936	33098	34816	38507	50423
Net Loans	1178285	1351512	1539447	1774159	1997625
Deposit	1644738	1926194	2146689	2433810	2732262
Total Liabilities	2012155	3043457	3021923	3767380	4210905
Total Equity	216909	168544	204287	247756	309783
SPDB					
Total Assets	2684694	3145707	3690125	4195924	5044352
Total Loans	1331436	1544553	1767494	2028380	2245518
Loan Loss Allowance	291121	35747	41749	53766	74105
Net Loans	1040315	1508806	1725745	1974614	2171413
Deposit	1851055	2134365	2419696	2724004	2954149
Total Liabilities	2535151	2966048	3472898	3932639	4725752
Total Equity	149543	179659	217227	263285	318600
BIC					
Total Assets	2408798	3250975	3677435	4406399	5298880
Total Loans	983254	1229165	1357057	1593148	1779408
Loan Loss Allowance	14314	24623	36375	43896	54586
Net Loans	968940	1204542	1320682	1549252	1724822
Deposit	1345279	1813266	2170345	2267780	2483923
Total Liabilities	2292720	3080340	3476264	4145303	4981503
Total Equity	116078	170635	201171	261096	317377

BJB					
Total Assets	956499	1119969	1336764	1524437	1844909
Total Loans	405609	396521	584862	675288	775390
Loan Loss Allowance	9543	13275	16010	20570	27473
Net Loans	396066	383246	568852	654718	747917
Deposit	614241	713772	834480	922813	1022300
Total Liabilities	906065	1048278	1258458	1428293	1728095
Total Equity	50434	71691	78306	96144	116814
HZB					
Total Assets	243937	324984	340188	418541	545314
Total Loans	126846	152139	173692	196657	215256
Loan Loss Allowance	2686	3798	4374	4624	5682
Net Loans	124160	148341	169318	192033	209574
Deposit	182045	220689	249273	279680	312046
Total Liabilities	229509	307452	319575	392379	513420
Total Equity	14428	17532	20613	26162	31894
					Unit: million CNY

Annexes 5: Number of Employees of Banks from 2011 to 2015

	2011	2012	2013	2014	2015
ICBC	408859	427356	441902	462282	466346
CCB	329438	348955	368410	372321	369183
ABC	447401	461100	478980	493583	503082
BOC	271644	283977	295197	299097	305675
BOCM	90149	96331	98919	93658	99122
CMBC	45344	59340	68078	75109	76192
CMSB	40820	49227	54927	59659	59510
BIC	34611	42561	47841	50214	50472
CITIC	37195	41365	46822	50735	56489
SPDB	31231	35784	38976	43654	48427
BJB	7339	8259	9193	10401	13776
HZB	3480	4201	4859	5350	5763